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Sub-Part A – VEHICLE DESCRIPTION

SECTION 1 GENERAL DESCRIPTION

1.A. GENERAL OVERVIEW OF THE PROPOSED VEHICLE

1.A.1. INTRODUCTION TO URBOS STREETCAR PLATFORM

CAF's standard streetcar platform, URBOS, has been in revenue service since 2000. The URBOS family is a state-of-the-art streetcar platform. The future of CAF's URBOS streetcar is extremely promising as cities around the world are looking to improve urban mobility with greener and more user-friendly solutions. In the last few years, CAF has been awarded many contracts for its URBOS streetcars, including Cincinnati and Kansas City (USA), Birmingham and Edinburgh (UK), Sidney (Australia), Kaohsiung (Taiwan), Freiburg (Germany), Cuiaba (Brazil), Budapest (Hungary), Saint Etienne (France), Utrecht and Amsterdam (The Netherlands), and Luxembourg (Luxembourg). CAF's opportunity to innovate and implement new solutions is growing with each contract.

Figure 1. *Overview of some of the CAF streetcars: Zaragoza, Cincinnati, Birmingham, Besançon*

CAF is excited about the opportunity to provide the City of Seattle with CAF's latest generation of streetcars. CAF has adapted the URBOS platform to meet US standards. The URBOS US is a continuation of the fully flat, 100% low-floor platform that successfully operates in a growing number of transit systems throughout the world. No steps or ramps in the passenger compartment allow one of the best dwell times and interior passage flows in the US market. All this provides the operator with an efficient and agile rolling stock fleet, which translates directly into high passenger satisfaction rates. We are committed to working closely and collaboratively with the City of Seattle to ensure that our streetcars meet your needs.

The proposed streetcar is an electrically propelled vehicle based on the URBOS family, a 100% flat and low floor Streetcar platform developed by CAF in response to the growing market demand for easy access, level boarding transportation solutions.

1.A.2. URBOS MODULAR DESIGN

URBOS Streetcars are bi-directional and come in consists of 3, 5, 7, or 9 articulated modules joined together. Three different types of modules form the basis of the URBOS family:

- Truck-supported cab modules,
- Truck-supported intermediate modules, and
- Suspended modules.

These modules are combined to suit specific customer needs.

Figure 2. *URBOS Platform*

This modular concept offers a wide range of advantages such as the following:

- Light weight
- Modular design
- Anticipates future needs (e.g. a basic 3 module unit could be expanded to 5 modules)
- Provides ease of access (particularly for mobility impaired passengers)
- Navigates well on winding track sections with extremely small radius curves
- Low wheel wear

The streetcars typically have passenger doors on both sides, and comply with the requirements for accessibility and accommodation. The platform vehicles are supported by motor and trailer trucks. Depending on the number of modules, there are 2, 3, or 4 motor trucks (for 3 and 5 module units, 7 module units, and 9 module units respectively).

The streetcars are capable of achieving maximum speeds up to 50 mph. They operate as single units, and have provisions for emergency towing, but not for multiple-car operation. The equipment is designed for reliable operation in different climatic environments all over the world. The interiors are fully climate-controlled, and have ample seating, sufficient hand-holds for standing passengers, and space for wheelchairs, bicycles, strollers, etc.

The streetcars are Buy America-compliant, conform to the requirements of NFPA 130, and are fully compliant with ADA accessibility requirements.

1.A.3. VEHICLE DESCRIPTION

The design will be based on CAF's Cincinnati and Kansas City streetcars, currently in revenue service, as well as on CAF's extensive experience in vehicle design and manufacturing, as the proposed streetcar is based on the service-proven URBOS streetcar platform more generally.

Figure 3. *Exterior livery proposals*

Figure 4. Interior design proposals

Exterior and interior design proposals are included in Appendix 1.1.

1.A.3.1 CONFIGURATION

The proposed vehicle is a 100% flat and low floor, bidirectional, double-cab, articulated urban streetcar with an aesthetically pleasing, modern style. The vehicle consists of three body sections joined by two articulation sections to form the standard operating unit. The end modules rest on motor trucks, while the center module is suspended. The modules are designated as follows:

C1 (Cab Module) – S1 (Suspended Module) – C2 (Cab Module)

Figure 5. *Vehicle exterior side view*

The vehicle is 75.28' long (22.946 m) (length over couplers) and 7.87' wide (2.4 m).

The carbody was designed using innovative construction concepts and materials, resulting in optimized weight, simplified carshell manufacturing, and shortened time needed for integration and installation of equipment, due to their modularity.

The carbodies used for the streetcars are lightweight, integrated, sub-assembled structures which are constructed of High Strength Low Alloy (HSLA) steel with improved atmospheric corrosion resistance, Ultra High Strength Steel, and extruded profiles and plates of 6000 series aluminum alloy.

The trucks under the C1 and C2 modules are motor trucks, with one motor per wheel. The truck design is well-proven and used on all CAF 100% low floor vehicles. The trucks have independently rotating resilient wheels. The truck frame is fabricated from cast steel and welded plates.

The trucks will be equipped with a rubber steel bell-type primary suspension, and a secondary suspension composed of a spring suspension.

The proposed vehicle has 29 fixed seats. The AW2 capacity of the proposed vehicle is 120 passengers, consisting of 29 seated passengers and 91 standees at 4 p/m^2. The streetcar includes two dedicated spaces for wheelchair users and meets the ADA accessibility requirements. The streetcar also includes a zone to store two bicycles vertically. In addition, the wheelchair areas can be used to accommodate strollers, luggage, etc. when they are not in use by wheelchair users.

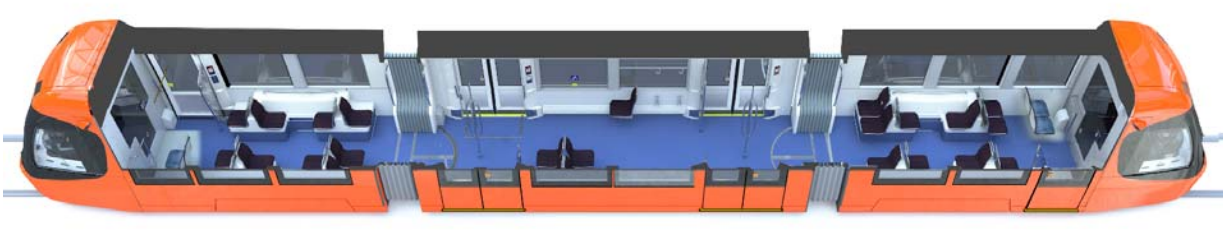


Figure 6. *Overview of the passenger compartment area*

The interiors of the driving cab and passenger compartment are designed using human factors methodologies, with the goal of providing a safe and pleasant environment and to facilitate rapid boarding and egress of passengers. The vehicle has service proven sliding-plug side doors, and provides a continuous low-floor throughout the passenger area. To improve the accessibility to

wheelchair users' in stations and therefore, be compliant with ADA regulations, ramps are provided in the intermediate module.

The majority of vehicle equipment is installed on the vehicle roof, making the equipment easily accessible. Rooftop equipment includes the power converters (including the traction inverters, auxiliary converter and battery charger), braking resistors, pantograph, onboard energy storage system (OESS), and HVAC systems.

The ends of the vehicle are equipped with an Albert-type coupler to allow mechanical and electrical connections for emergency towing.

1.A.4. SERVICE PROVEN PROPOSAL

The proposed streetcar is based on the URBOS US streetcar which is successfully in revenue service in Cincinnati and Kansas City. The following modifications have been adopted in order to make it compatible with the infrastructure of the City of Seattle:

1. Narrow the vehicle from 2650 mm to 2400 mm
2. Shorten the intermediate module

The OESS equipment is also a service proven solution. Vehicles in the cities of Seville and Zaragoza (Spain) and Kaohsiung (Taiwan) and shortly in the cities of Birmingham, Luxembourg, and Newcastle are prime examples of this service proven solution. Please refer to Sub-Part B for further details on the offered OESS.

Other differences with the service-proven solutions on URBOS US streetcar platform have been listed as Technical Deviations in Sub-Part G). These deviations will allow the City of Seattle to benefit from a service-proven design avoid higher maintenance costs and improve Life Cycle Cost with a common pool of Parts Suppliers from the URBOS US platform.

With this goal in mind, URBOS US platform technical solutions already implemented in US Projects will prevail over any discrepancies, if any, that may arise from undefined and/or unidentified technical requirement within the Technical Specification.

URBOS US platform standard technical documentation, approved in Cincinnati and Kansas City projects, will be used for the Design Reviews, with modifications strictly limited to incorporate the design modifications listed in the Technical Description.

1.A.5. PROVEN RELIABILITY

As previously stated, the proposed vehicle is based on the URBOS streetcar platform, which delivers state-of-the-art service all over the world through a successful and growing fleet of vehicles.

This streetcar platform includes a whole range of high-quality products, specifically designed and developed with the most relevant equipment suppliers, to guarantee and meet, the Reliability targets requested by customers worldwide, as well as other targets/specifications. Therefore, the URBOS platform's reliability is proven through all of the URBOS streetcars in service worldwide.

Please refer to Appendix 1.3 for further details on the reliability data of the proposed vehicle.

1.A.6. ALIGNMENT OR URBAN INTEGRATION

The proposed vehicle does not present the same architecture and outer dimensions as the existing vehicle of the City of Seattle.

It must be noted that the dynamic envelope provided in the drawings of Appendix A of the Technical Specifications belongs to the existing vehicle, where some normally used calculation parameters such as the superelevation were not considered. Besides, the envelope of the existing vehicle in R20m curve (drawing S121-0412) establishes the same horizontal movements as in tangent track, without including rotation movements between the truck and the carbody. Although the rail wear and rail gauge tolerances are apparently considered, their value is not defined.

Therefore, when performing gauge calculations to check the proposed vehicle's suitability (and make it comparable with the existing vehicle), the following assumptions have been made:

- Rail to flange play: 3.5mm
- Non-compensated lateral acceleration set to 0.0 (not defined in the Specifications)
- Track Gauge Tolerance (Maintenance), including Rail Wear: 10mm
- Cross level variation: 28.7mm (equivalent to 2%)
- Superelevation set to 0.0mm (although the Specifications indicate a maximum superelevation of 75mm)

The dynamic envelope considered under these assumptions is shown in drawing Q.00.238.00.040, included within Appendix 1.2.

Due to CAF's experience in performing these calculations for the infrastructures of different operators, CAF is confident in the suitability of the proposed vehicle. Nevertheless, this preliminary calculation will need to be confirmed once all existing vehicle calculation assumptions and infrastructure data are available at project phase.

1.A.7. ONBOARD ENERGY STORAGE SYSTEM

In support of the Green initiatives in the Seattle metropolitan area, CAF offers a complete Onboard Energy Storage System (OESS) solution to meet the growing market demand for catenary-free operation, energy savings, and reduction of power peaks. It is a cost effective system that reduces infrastructure costs by storing energy on-board the vehicle.

The proposed OESS design uses cutting-edge technology with the highest power/energy density on the market. OESS is becoming the new standard for energy savings, and its applications are becoming more common in the rail industry. Several of the projects CAF has recently been awarded are evidence of this increasing trend in the market. CAF's OESS solutions have been proven in revenue service since 2010.

CAF customizes the OESS equipment to the needs of each application, with consideration of the power, energy and infrastructure needs of each customer.

The OESS has been installed on the URBOS platform for several projects in cities in Europe and all over the world. It is already in revenue service in three different locations: Seville (Spain), Zaragoza (Spain), and Kaohsiung (Taiwan). Streetcars for Tallinn (Estonia) and Cuiaba (Brazil) have also been delivered with OESS system (EVODRIVE), and streetcars in the City of Granada (Spain) will shortly enter revenue service. Streetcars for Birmingham (UK) Luxembourg (Luxembourg) and Newcastle (Australia) are also in an advanced stage of the design and manufacturing process.

Figure 7. *Zaragoza (Spain) and Kaohsiung (Taiwan) streetcars*

Figure 8. *Seville (Spain) and Luxembourg (Luxembourg) streetcars*

This experience makes CAF one of the leading suppliers of streetcars fitted with OESS systems.

1.A.7.1 STREETCAR MODIFICATIONS

The streetcar is designed for conventional service, with the addition of the OESS designed for operation in off-wire sections. There are no major differences between the URBOS Streetcar and the URBOS Streetcar with OESS, other than the addition of the OESS equipment.

The streetcar equipped with OESS operates as a conventional streetcar if the OESS is not operating. Maintenance of the OESS is similar to any conventional electrical equipment.

The OESS can be mounted in any of the configurations of the URBOS Streetcar platform.

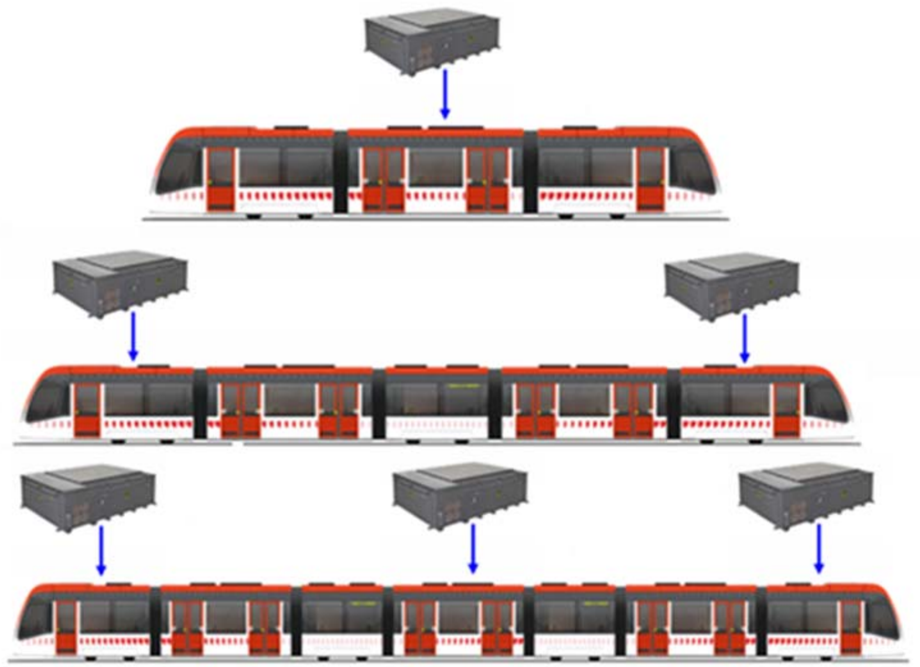


Figure 9. OESS Solutions For Various Configurations of the URBOS Platform

The URBOS Streetcar platform, originally designed to European standards, has been modified to comply with US standards and is in use in Cincinnati and Kansas City.

1.A.8. OESS EQUIPPED STREETCAR INFORMATION

1.A.8.1 CONVENTIONAL STREETCAR

On a conventional streetcar, energy is supplied between stations by the catenary for traction and auxiliaries.

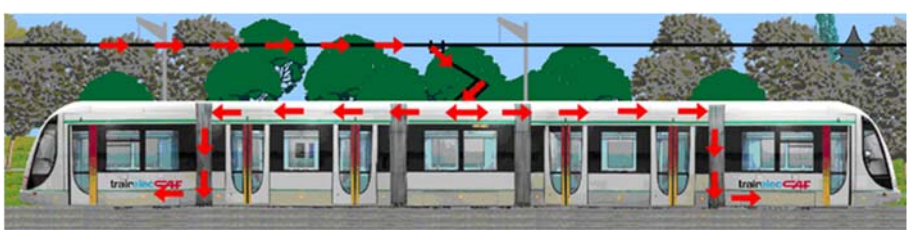


Figure 10. Traction Phase: Between Stations

When the vehicle arrives at the stations, some kinetic energy is returned to the catenary while braking, and the rest is dissipated into the braking resistors.

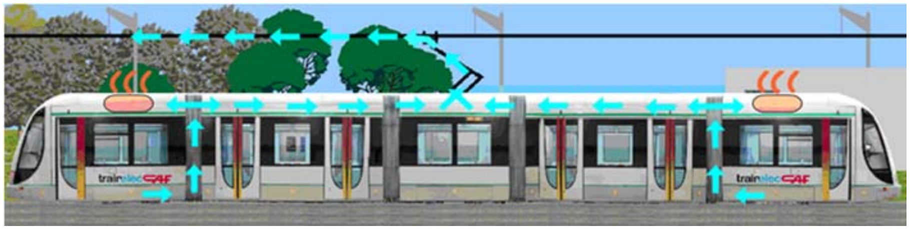


Figure 11. Braking Phase Arriving at the Stations

1.A.8.2 CAF ON-BOARD ENERGY STORAGE SYSTEM

In order to use the energy returned to the catenary and the dissipated energy in the braking resistors, CAF has developed its own equipment for energy efficient and catenary-free streetcar operation. The system proposed by CAF is the result of an extensive process of analysis, research, and development.

1.A.8.2.1 OESS PRODUCT DESCRIPTION

The OESS Box is an on-board energy storage system geared towards catenary-free operation, using Lithium-Ion batteries. This technology, besides making it possible to eliminate the catenary in some sections, improves the energy efficiency of the train, recovering and storing the energy released throughout the catenary sections of the route, and during braking throughout the entire route, in both catenary and catenary free sections.

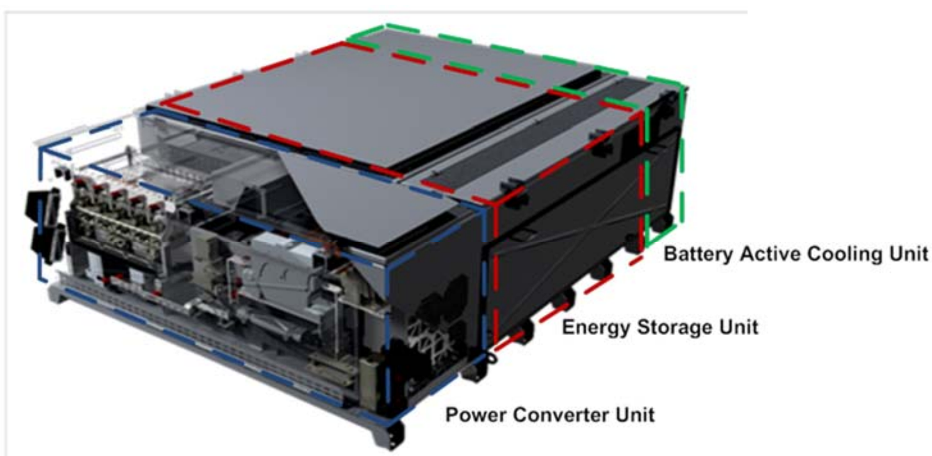
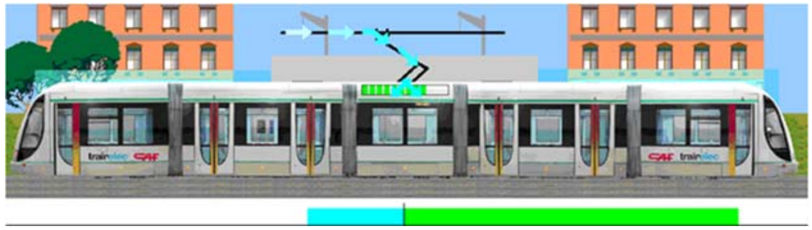


Figure 12. OESS Box Equipment Composition

- The Power Converter Unit (represented in blue in the drawing above) controls the Energy Storage Unit charging and discharging.
- The Energy Storage Unit is represented in red in the drawing below.
- Battery Active Cooling Unit for the cooling of the system.

The system is modular, configurable, and redundant.



1.A.8.2.2 DIMENSIONING

CAF has experience in dimensioning the system. For that purpose, simulations and calculations are performed to predict the energy and power requirements. Based on the results obtained, the number of modules (and therefore, the number of OESS boxes) is selected.

Please refer to Sub-Part B Onboard Energy Storage System (OESS) for further information about the power requirements needed for this project.

1.A.8.3 CHARGING PROCESS

The charging process is done throughout the sections of the route with catenary sections.

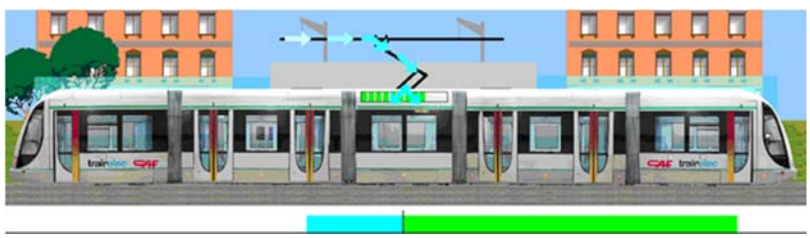


Figure 13. *Charging Phase: At the Stations*

Before reaching the catenary-free sections, the On-board Energy Storage System (OESS) is charged by the catenary.

Figure 14. *Traction Phase: Between Stations*

In the catenary-free section, with the pantograph down, the energy is supplied by the OESS for traction and auxiliaries.

Figure 15. *Braking Phase Arriving at the Stations*

As the vehicle approaches a station stop, the kinetic braking energy is saved by the OESS (instead of being returned to the catenary or dissipating through the braking resistors).

At the end of the catenary-free section, the pantograph will go up again; the vehicle will continue operating normally and the OESS will be charged through the catenary.

1.B. CONCEPTUAL DESIGN DRAWINGS

The following appendices provide general arrangements drawings and preliminary artist renderings. Some of the drawings included in Appendix 1.2 are referenced elsewhere in this proposal, but have been also included here so that all drawings remain grouped.

- Appendix 1.1: Preliminary artist renderings
- Appendix 1.2: Drawings
  - Q.00.238.00.000: General Unit Assembly, with exterior and interior arrangement
  - Q.00.238.00.020: Capacity, with floor plan, including passenger seats and standee area
  - Q.00.238.00.030: Transverse sections
  - Q.00.238.00.031: Longitudinal section, with interior (non-)step arrangement
  - Q.00.238.00.040: Dynamic Envelope
  - Q.00.238.00.045: Platform accessibility – Door without ramp
  - Q.00.238.00.046: Platform accessibility – Door with ramp
  - Q.00.238.18.001: Coupler
  - Q.00.238.66.001: HVAC
  - Q.00.238.72.001: Underframe Equipment Arrangement
  - Q.00.238.73.001: Roof Equipment Arrangement
  - Q.00.238.74.001: Vehicle interior equipment arrangement
  - Q.00.238.86.001: Cab console arrangement
  - Q.00.238.87.001: General cab assembly
  - L.00.860.00.000: Truck

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SECTION 2 SYSTEM REQUIREMENTS

2.A. DYNAMIC PERFORMANCE

2.A.1. PROPULSION AND BRAKING PERFORMANCE

2.A.1.1 PERFORMANCE PARAMETERS

Traction and braking performance. Normal mode with 0% slope.	
Maximum speed service	70 km/h
Vehicle load for traction	AW2
Maximum acceleration	1.34 m/s2
Mean acceleration from 0 to 32 km/h (without Jerk)	1.32 m/s2
Mean acceleration from 0 to 32 km/h (with Jerk)*	1.25 m/s2
Vehicle load for braking	AW3
Maximum deceleration	1.34 m/s2
Mean electrical deceleration from 70 to 0 km/h (without Jerk)	1.27 m/s2
Mean electrical deceleration from 70 to 0 km/h (with Jerk)*	1.22 m/s2
Traction rated voltage	750 Vdc
Braking rated voltage	900 Vdc

Table 1. *Main performance values*

Performance requirements: Time and distance.

Speed	20km/h	30km/h	40km/h	50km/h	70km/h
Time(sg)	5.46	7.54	9.61	11.68	16.56
Distance (m)	17.25	34.49	57.49	86.25	173.86

Table 2. Acceleration: Time and distance requirements

2.A.1.2 TRACTION PERFORMANCE

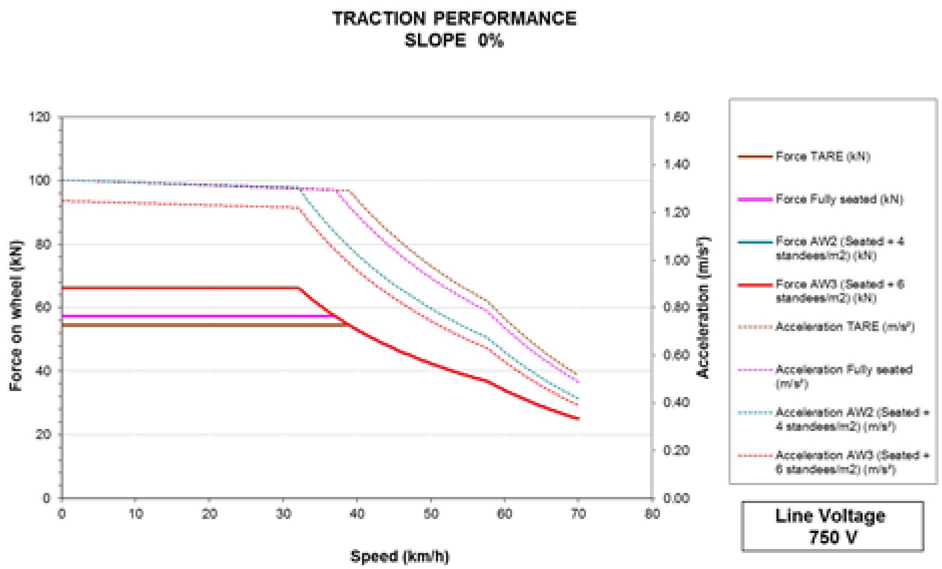


Figure 1. Traction performance graph

2.A.1.3 BRAKE PERFORMANCE

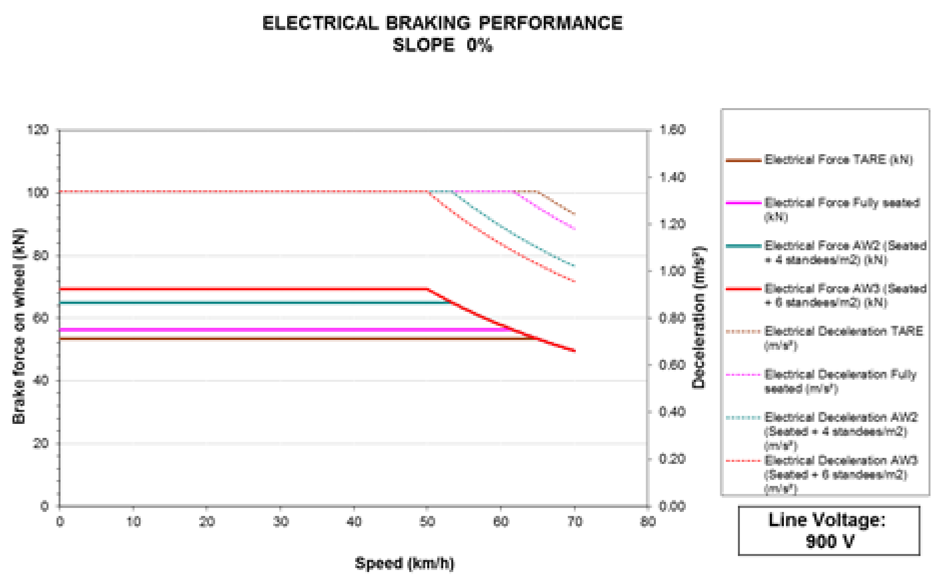


Figure 2. Traction performance graph

The deceleration shown in the graph above (figure 2) is produced by the single use of the electrical braking system. In normal operation, the Service Brake will be composed of the electrical and friction braking system, and will provide a constant deceleration of 1.34 m/s^2 in the whole speed range, as requested by the technical specification.

2.A.2. TOP SPEED PERFORMANCE DIAGRAMS

2.A.2.1 UNDER CATENARY PERFORMANCE

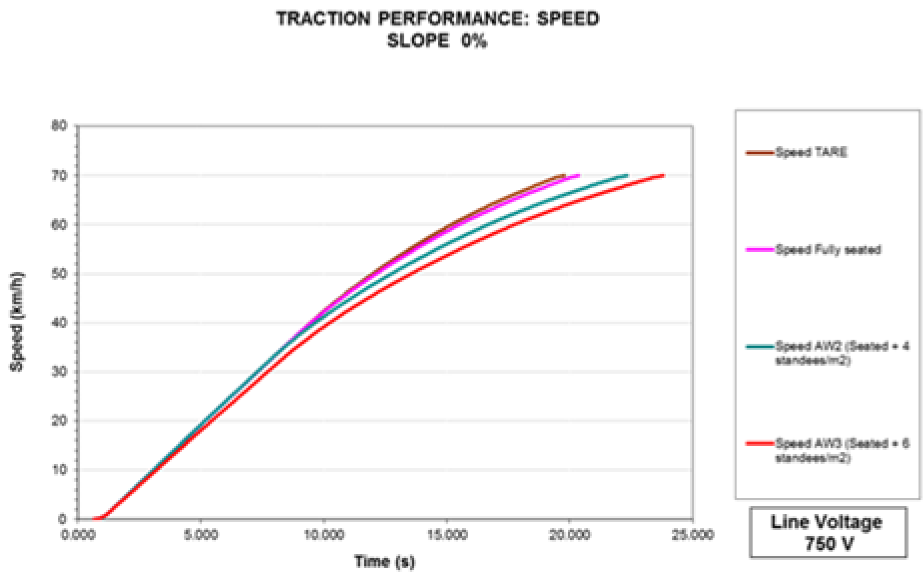


Figure 3. Performance: Speed vs time

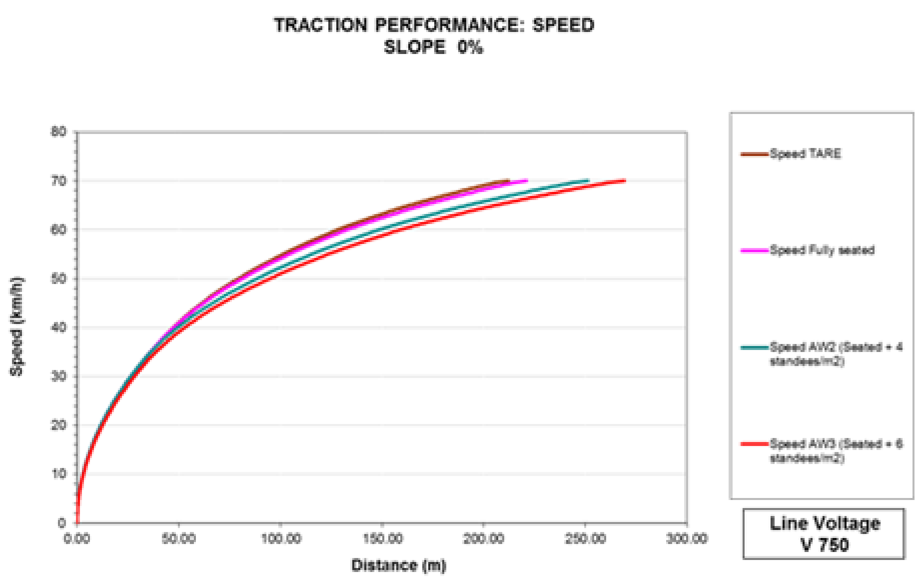


Figure 4. Performance: Speed vs distance

2.A.2.2 OFF-WIRE (OESS) PERFORMANCE

Traction and braking electrical perfomances. Normal mode with 0% slope.	
Maximum speed service	70 km/h
Vehicle load for traction	AW2
Maximum acceleration	1.34 m/s2
Mean acceleration from 0 to 7.4 km/h (without Jerk)	1.32 m/s2
Mean acceleration from 0 to 7.4 km/h (with Jerk)*	1.25 m/s2
Vehicle load for braking	AW3
Maximum deceleration	1.34 m/s2
Mean electrical deceleration from 70 to 0 km/h (without Jerk)	1.27 m/s2
Mean electrical deceleration from 70 to 0 km/h (with Jerk)*	1.22 m/s2
Traction rated voltage	750 Vdc
Braking rated voltage	900 Vdc

Table 3. *Off-wire main performance values*

The deceleration described in table 3 is produced by the single use of the electrical braking system. In normal operation, the Service Brake will be composed by the electrical and friction braking system, and will provide a constant deceleration of 1.34 m/s2 in the whole speed range, as requested by the technical specification.

In the table below, the maximum acceleration rate and maximum (balancing) speed achievable can be seen. The acceleration and speed have been calculated at AW0 and AW3 on level tangent track, on a 2%, 4%, 6% and on a 9% uphill grade.

2.A.2.2.1 NORMAL MODE:

Minimum adhesion for maximum acceleration		TARE	Fully seated	AW2 (Seated + 4 standees/m2)	AW3 (Seated + 6 standees/m2)
2 %	**Minimum adhesion**	**0.16**	**0.16**	**0.16**	**0.15**
	Maximum acceleration (m/s²)	1.15	1.15	1.15	1.06
4 %	**Minimum adhesion**	**0.16**	**0.16**	**0.16**	**0.15**
	Maximum acceleration (m/s²)	0.97	0.97	0.96	0.88
6 %	**Minimum adhesion**	**0.16**	**0.16**	**0.15**	**0.14**
	Maximum acceleration (m/s²)	0.79	0.78	0.78	0.69
9 %	**Minimum adhesion**	**0.15**	**0.15**	**0.15**	**0.14**
	Maximum acceleration (m/s²)	0.51	0.51	0.50	0.41

Table 4. *Performance: Ramp start. Normal mode*

2.A.2.2.2 DEGRADED MODE (75% OF TRACTION AVAILABLE)

Minimum adhesion for maximum acceleration		TARE	Fully seated	AW2 (Seated + 4 standees/m2)	AW3 (Seated + 6 standees/m2)
2 %	**Minimum adhesion**	**0.16**	**0.16**	**0.15**	**0.10**
	Maximum acceleration (m/s²)	0.81	0.81	0.81	0.42
4 %	**Minimum adhesion**	**0.15**	**0.15**	**0.15**	**0.09**
	Maximum acceleration (m/s²)	0.63	0.63	0.62	0.24
6 %	**Minimum adhesion**	**0.15**	**0.15**	**0.15**	**0.10**
	Maximum acceleration (m/s²)	0.44	0.44	0.44	0.10
9 %	**Minimum adhesion**	**0.15**	**0.15**	**0.15**	**0.14**
	Maximum acceleration (m/s²)	0.17	0.17	0.16	0.10*

Table 5. *Performance: Ramp start. Degraded mode*

2.A.2.2.3 TRACTION CURVE (OESS)

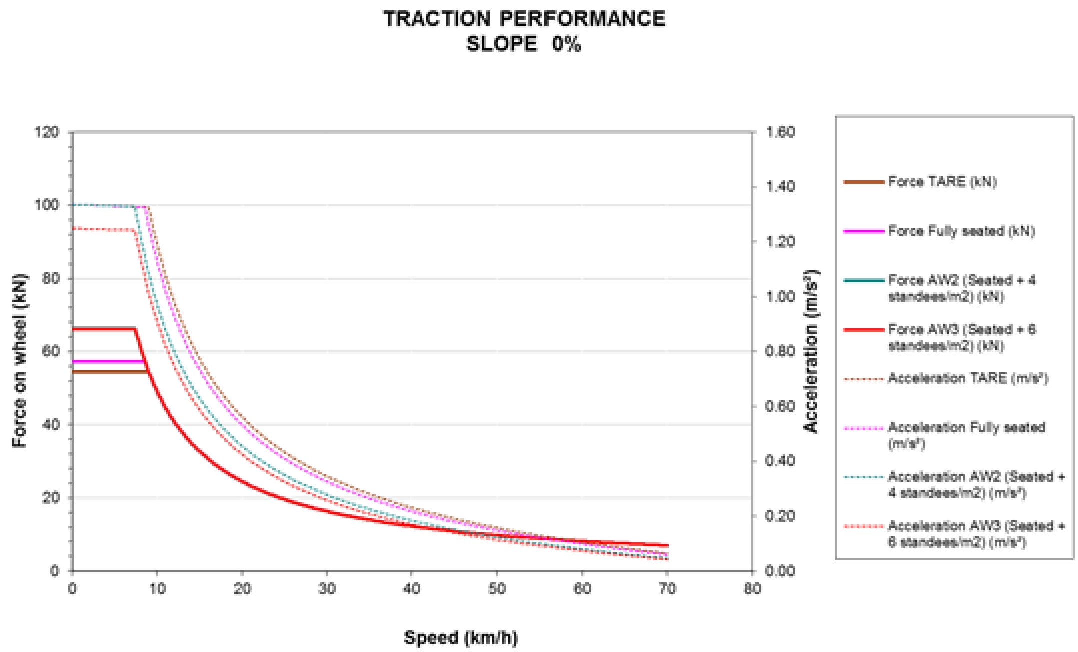


Figure 5. *Tractive effort curve: Off-wire operation*

2.A.2.2.4 BRAKING CURVE (OESS)

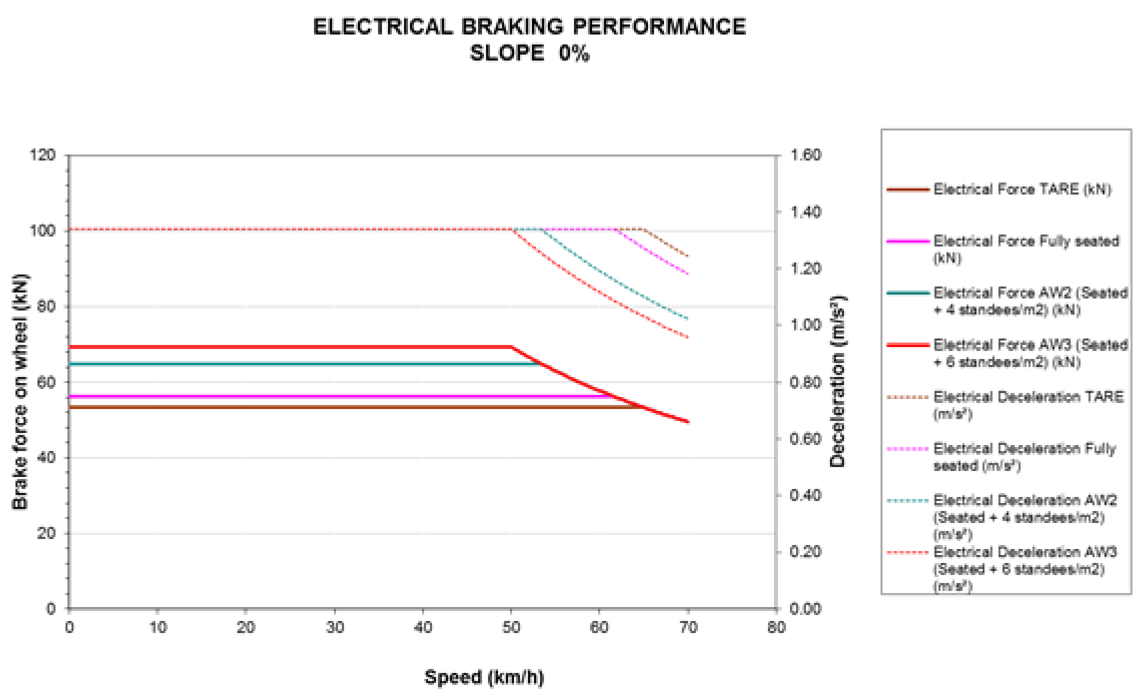


Figure 6. *Tractive effort curve: Off-wire operation*

As explained previously, the deceleration shown in the figure above is produced by the electrical braking system. In normal operation, the service brake will be composed of both, electrical and friction braking, and will provide a constant deceleration of 1.34 m/s^2 as requested by the technical specification.

2.A.3. FRICTION BRAKING PERFORMANCE

In the following sub-sections, the performance achieved by the friction braking system will be described. The performance results have been calculated and validated in a train similar to the one described in this proposal.

In general, the braking system described in this proposal is well suited to the requirements. The calculated braking performance and adhesion demand allow room for adjustment on the final vehicle and for blending at speeds with reduced ED effort. Stopping rates and distances in the calculations (except for the parking brake) are based on level tangent track.

2.A.3.1 FULL SERVICE BRAKING

FULL SERVICE BRAKE							
Description		*Initial Speed (km/h)*	*Load Condition*	*achieved 'ae' (m/s2)*	*achieved average deceleration (m/s2)*	*Max µ wheel to rail*	*Stopping distance (m)*
NORMAL MODE		70	AW0	1,34	1,17	14,0%	161,0
			AW3	1,34	1,18	14,0%	160,0
DEGRADED MODE	MODE 1	70	AW0	1,34	1,19	17,0%	158,0
	(50% EDB Out)		AW3	1,34	1,20	15,0%	158,0
	MODE 2	70	AW0	0,81	0,75	17,0%	251,0
	(1 TCU Out)		AW3	0,72	0,67	15,0%	282,0
	MODE 3	70	AW0	1,34	1,17	14,0%	161,0
	(50% FB Out)		AW3	1,34	1,18	14,0%	160,0
	MODE 4	70	AW0	1,34	1,22	14,0%	155,0
	(100% EDB Out)		AW3	1,34	1,22	14,0%	155,0
TOWING MODE		70	Operative AW0 tows inoperative AW0	0,56	0,53	14,0%	358,0
			Operative AW0 tows inoperative AW3	0,67	0,63	14,0%	301,0

Figure 7. *Full service braking*

2.A.3.2 EMERGENCY BRAKING

MAXIMUM BRAKE (EMERGENCY 3)						
Description	*Initial Speed (km/h)*	*Load Condition*	*achieved 'ae' (m/s2)*	*achieved average deceleration (m/s2)*	*Max µ wheel to rail*	*Stopping distance (m)*
NORMAL MODE	70	AW0	1,91	1,77	13,0%	107,0
		AW3	1,76	1,63	13,0%	116,0

Figure 8. *Emergency 3 braking*

EMERGENCY BRAKE (EMERGENCY 4)							
Description		Initial Speed (km/h)	Load Condition	achieved 'ae' (m/s2)	achieved average deceleration (m/s2)	Max µ wheel to rail	Stopping distance (m)
SECURITY BRAKE	only FB	25	AW0	1,8			
			AW3	1,30			
	FB+MTB		AW0	2,76			
			AW3	1,99			
	ED+FB+MTB		AW0	2,76	2,28	18,0%	11,0
			AW3	2,85	2,23	22,0%	11,0
	only FB	70	AW0	1,8	1,71	18,0%	111,0
			AW3	1,30	1,24	13,0%	152,0
	FB+MTB		AW0	2,38	2,23	18,0%	85,0
			AW3	1,71	1,63	13,0%	116,0
	ED+FB+MTB		AW0	2,38	2,23	18,0%	85,0
			AW3	2,58	2,36	22,0%	80,0

Figure 9. *Emergency 4 braking*

2.A.3.3 PARKING BRAKE

PARKING BRAKE				
Description	Slope (%)	Load Condition	µ wheel to rail	Safety factor SLIDING
NORMAL MODE	9.0	AW0	9.0%	2,30
		AW3		1,62
		AW4		1,50

Figure 10. *Parking brake*

2.A.4. RIDE QUALITY

An optimization study is carried out during the dynamics design process to obtain the optimum values for the suspension parameters. This study consists of a detailed analysis of the frequency response where the transfer function between track irregularities and carbody accelerations is obtained. Additionally, iterative simulations are carried out on a track with irregularities, where the influence of each suspension parameter on ride comfort is assessed.

These simulations provide the necessary information for an accurate selection of parameters, which will ensure that a comfortable ride is provided as long as the track does not present major irregularities. It is important to note that for these simulations to be as useful and realistic as possible, representative measured track data is required.

Based on previous satisfactory results in different projects, CAF is confident that through application of the same methodology, the proposed streetcars will meet the requirements of ride comfort established in Section 2 of the Technical Specification when running in normal vehicle conditions.

Ride quality tests will be carried out according to the standard ISO 2631 using one of the first manufactured streetcars, in order to demonstrate that the mentioned specification is fulfilled.

1. Root mean square (rms) acceleration values: maximum 0.32 m/s^2 in each direction for each measurement point for operators and passengers, seated or standing.
2. Vibration total value (root sum of squares summation): maximum 0.5 m/s^2 when calculated for each measurement point.
3. Acceleration data will be evaluated over the range of 0.5 Hz to 80 Hz, as required by the standard ISO 2631. Wb frequency weighting will be used instead of Wk for the accelerations in vertical direction.

These tests will be performed at a representative track section of the line at which the vehicle will operate.

Prior to testing, a test procedure will be prepared and approval obtained from the Owner. This procedure will include the tests conditions, which will take into account the ones specified in the Technical Specification:

1. As a minimum, the test will be carried out at speeds of 40 and 70 km/h (25 and 43 mph).
2. Two load conditions will be tested: AW0 and AW1.
3. Accelerations will be measured in the following points, on the vehicle floor above the intersection of the vehicle longitudinal centerline:
   a. An end truck transverse center line
   b. The center of the vehicle between trucks
   c. At three seat locations at the bottom of the seat
4. In each point lateral and vertical accelerations will be measured. The longitudinal acceleration will be measured at the center of the vehicle.

5. Accelerations will be measured over the frequency range of 0.5 Hz to 80 Hz.
6. Tests will be carried out in a normal revenue service operation conditions.

2.B. PERFORMANCE SIMULATION OVER A COMPLETE ROUND TRIP

2.B.1.1 SIMULATION CONDITIONS

These are the conditions used for the simulations:

- Unit configuration: C1-S- C2 (3 modules)
- Track speed limit: 48 km/h
  - Off-wire: 25 km/h
  - On-wire: 48 km/h
- Catenary voltage: 750V for traction and 900V for braking
- Performance curves defined
  - For on wire performances, in section A.1 of this document
- Load: AW3 (6p/m^2)
- Rotary inertia: 6.87% tare
- Gear-box ratio: 5.44
- Rated wheel diameter: 585 mm
- Stations dwell time: 20 seconds
- Jerk: 2 m/s^3
- Total brake rate: 1.34 m/s^2
- Simulation mode: All-Out -maximum performance-
- Non-compensated (lateral) acceleration: 1 m/s^2

As a result of the simulations the following parameters are obtained for the train:

- Power at wheel
- Force at wheel
- Speed

Following are the graphical results of the simulations:

2.B.1.2 SIMULATION RESULTS

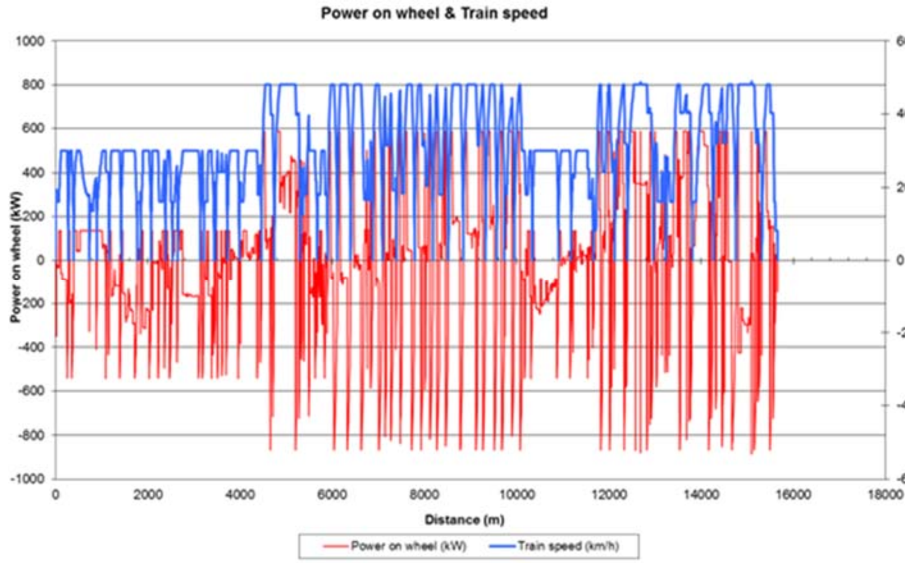


Figure 11. Simulation result 1: Power on wheel

Figure 12. Simulation result 2: Force on wheel vs time

Figure 13. Simulation result 3: Force on wheel vs distance

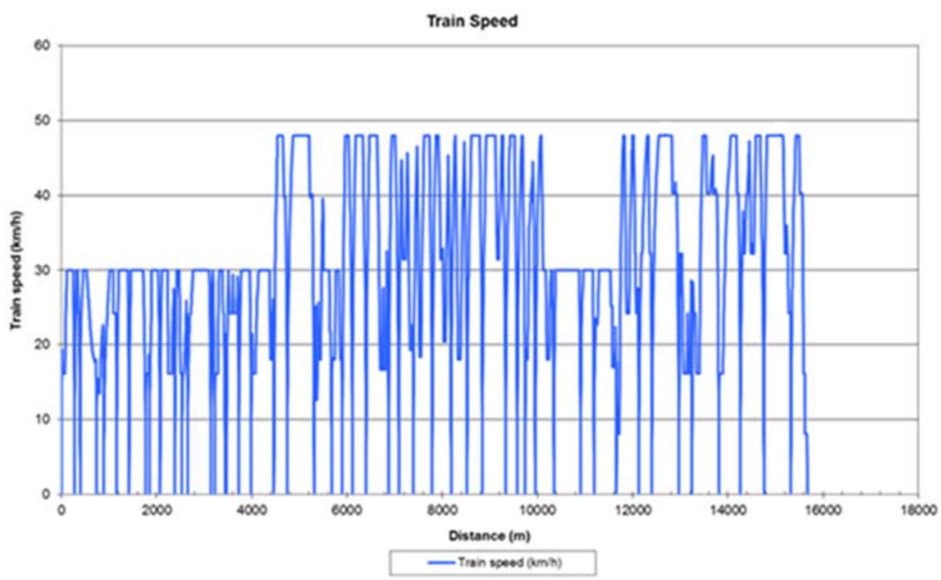


Figure 14. Simulation result 4: Train speed vs distance

2.B.1.3 ENERGY CONSUMPTION SIMULATION – OESS SECTIONS

2.B.1.3.1 TIMING AND ENERGY CONSUMPTION

These simulations are prepared in order to analyze the energy consumption of the unit for the route of First Hill.

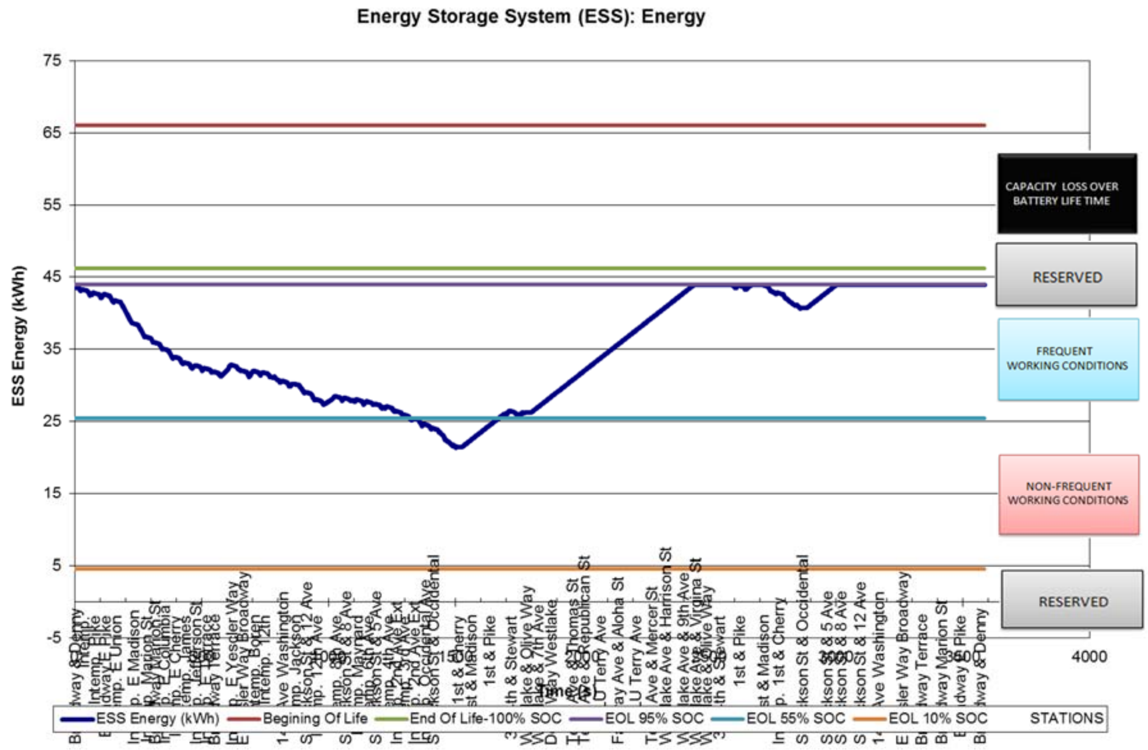
The conditions used for the simulations area as follows:

- Streetcar configuration: C1-S- C2 (3 modules)

- Track speed limit: 48 km/h
  - Off-wire: 25 km/h
  - On-wire: 48 km/h
- Catenary voltage: 750V for traction and 900V for braking
- Performance curves defined
  - For on wire performances, in section 2.A.1 of this document
- Load: AW2 (4p/m^2)
- Rotary inertia: 6.87% tare
- Gear-box ratio: 5.44
- Rated wheel diameter: 585 mm
- Stations dwell time: 20 seconds
- Jerk: 2 m/s^3
- Total brake rate: 1.34 m/s^2
- Simulation mode: All-Out -maximum performance-
- Non-compensated (lateral) acceleration: 1 m/s^2
- Unexpected stops: Traffic lights and at all cross streets
- Unexpected stop and Stations: 20secs.
- Considered auxiliary power: 30 kW

Following are the simulation results, including the route wireless segment time (in seconds) and the consumed energy in that segment.

Wireless Segments	TIME	Energy consumption (traction + auxiliary)
Broadway and Denny to South Jackson and Occidental Stations	1430.3 sg	31.5 kWh
Jackson and Occidental Stations to First and Cherry Stations	77.8 sg	2.85 kWh
Stewart and 2nd to Westlake and 6th Stations	85.9 sg	1.1 kWh
Stewart and 2nd to Jackson and Occidental Stations	273 sg	4.95 kWh



2.C. BRAKING SYSTEM PERFORMANCE CALCULATIONS

Please refer to section 2.A.3 of this document for the braking performance calculations.

2.D. ANTICIPATED CAR WEIGHT AND AXLE WEIGHT DISTRIBUTION

The following table shows the anticipated Vehicle weight and axle weight distribution.

	PASSENGER CRITERIA	No. of passengers	Total Weight (kg) (*)	C1-bogie mean axle weight (kg)	C2-bogie mean axle weight (kg)
AW0	Empty vehicle operating weight, max. 1710 kg/m (1150 lbs/ft)	0	36950	9364	9111
AW1	Full seated load (passengers plus operator), plus AW0	29 + 1	39050	9889	9636
AW2	Standees at 4 persons/m² plus AW1	120 + 1	45420	11482	11228
AW3	Standees at 6 persons/m² plus AW1	165 + 1	48570	12269	12016

***Table 1.** Anticipated Vehicle Weight*

(*) at 70 kg per passenger

2.E. EXTERIOR AND INTERIOR NOISE DATA

2.E.1. INTRODUCTION

The following section shows exterior and interior noise values for the proposed vehicle. These values are in line with previous measured data from equivalent CAF vehicles so proposed values are based on data from existing vehicles.

2.E.2. INTERIOR NOISE

The following table shows proposed values for the interior noise during both standstill and running conditions. All values are proposed according ISO3381 guidelines:

INTERIOR NOISE
The noise level inside the streetcar, on passenger's areas, will average no more than 68dBA when vehicle is at standstill condition, vehicle empty and auxiliary systems operating under normal conditions. The maximum internal noise level on driver's cab when vehicle is at standstill will not exceed 65dBA when vehicle is at standstill condition and HVAC system working on cooling mode.
The noise level inside the streetcar will average no more than 75dBA when vehicle is running at any speed up to 56km/h (35mph), and under any acceleration or deceleration condition.
The noise level inside the streetcar will not exceed 48dBA at 300mm (12in) from any lighting fixture energized at rated voltage and frequency.

Table 2. *Exterior noise values*

2.E.3. EXTERIOR NOISE

The following table shows proposed values for the exterior noise for both standstill and running conditions. All values are proposed according ISO3095 guidelines:

EXTERIOR NOISE
The maximum exterior noise level LpAeq20s will not exceed 70dBA measured at 7,5m (24,6 feet) from the track centerline and at a height of 1,5 m (4,9 feet) from the top of rail, when vehicle is at standstill condition, vehicle empty, auxiliary equipment operating and HVAC Units in normal mode operation. The maximum noise level LpAeqT, where "T" represents the measurement time, measured at 7,5m (24,6 feet) from the track centerline and at a height of 1,5m (4.9 feet) from the top of rail, when vehicle running up to 35 mph under free field conditions and ballasted track, will not exceed 75dBA.

Table 3. *Exterior noise values*

2.F. EVIDENCE OF SERVICE PROVEN DESIGN FOR SYSTEMS AND COMPONENTS

The proposed streetcar is based on the URBOS US streetcar which is in successful revenue service in Cincinnati and Kansas City. The following modifications have been adopted in order to make it compatible with the infrastructure of The Center City Connector:

1. Narrow the vehicle from 2650 mm to 2400 mm
2. Shorten the intermediate module

The OESS equipment is also a service proven solution. Vehicles in the cities of Seville and Zaragoza (Spain) and Kaohsiung (Taiwan) and shortly in the cities of Birmingham, Luxembourg, and Newcastle are good examples of this service proven solution. Please refer to Sub-Part B for further details on the offered OESS.

Other differences with service-proven solutions on URBOS US streetcar platform have been listed as technical Deviation in Sub-Part G. These deviations will allow the City of Seattle to benefit from a service-proven design avoiding higher maintenance costs and improve Life Cycle Cost with a common pool of Parts Suppliers from the URBOS US platform.

With this goal in mind, URBOS US platform technical solutions, already implemented in US Projects, will prevail over any discrepancies, if any, that may arise from undefined and/or unidentified technical requirement within the Technical Specification.

URBOS US platform standard technical documentation, approved in Cincinnati and Kansas City projects, will be used for the Design Reviews, with modifications strictly limited to incorporate the design modifications listed in the Technical Description.

TABLE OF CONTENTS

Sub-Part A – VEHICLE DESCRIPTION

Sub-Part A – VEHICLE DESCRIPTION

SECTION 3 CARBODY REQUIREMENTS

3.A. NARRATIVE PROPOSAL

3.A.1. CARBODY DESCRIPTION

3.A.1.1. CARSHELL

The carshell for the streetcar is comprised of three modules. It was designed by CAF Engineering using innovative construction concepts and materials.

These innovations are focused on three basic objectives:

- To optimize the weight of the unit, with the aim of reducing energy consumption required for traction.
- To simplify the manufacturing process to make the unit more competitive.
- To reduce the necessary maintenance and repair.

The carshell can be defined as a mixed structure because of the diversity of material employed. The structure is constructed of the following materials:

- High Strength Low Alloy (HSLA) steel with improved atmospheric corrosion resistance (Underframe and Sides).
- Ultra High Strength Alloy steel located in specific areas.
- 6000 Series Aluminum for extruded profiles and plates (roof and end plates).
- Composite materials, consisting of a thermoplastic foam core sandwiched between fiberglass and phenolic resin or polyester fabrics, are used for the cab exterior.

As the design of the URBOS 3 streetcar platform is continuously evolving from project to project, CAF uses its experience to improve its vehicles' characteristics for each project. The modularity of the side structures of the streetcar is one of the improvements successfully applied on streetcar projects, such as in Cincinnati and Kansas City. The side structures have been divided into fundamental sections or modules. These sections are joined using high-strength huck bolts and rivets and bolted joints instead of welded joints, improving the reparability characteristics of the structure.

3.A.1.1.1. UNDERFRAME

The underframe of the different modules are designed with carbon steel plates, forged and welded.

The underframes of the modules with trucks contain the necessary structural elements for the connection with the truck. The underframes are also designed to allow for the low floor in the central section.

Cab End Modules

There are three fundamental parts of the cab end modules:

- Truck area (Central Bogie Area in the drawing), the truck area is made of carbon steel, including the truck connections. It rests directly on the truck, by means of a box-like enclosure, and the entire vertical load is transmitted through it. The truck-to-carbody connections and the relative movements between them are the main issues involved in the design of this part. This area includes rigid areas to connect the carbody structure to the truck and provide structure to accommodate the seating areas of cab modules C1 and C2.
- Rear end bolster (Rear Headstock in the drawing), located at the end of the underframe where the articulation joint is mounted. It is specially designed to support the loads transmitted from one module to the other (or through the lower ball joint). The frame is rigid enough to minimize its deflection under passenger load. A stainless steel sheet is mechanically fastened to the bottom of the underframe in order to comply with NFPA 130.
- Cab end platform (Front Platform in the drawing), the door platform between the truck and the cab of cars C1 and C2. It is constructed of steel plates and profiles. It is also protected by a stainless steel sheet (for the NFPA 130) riveted to the bottom of the structure.

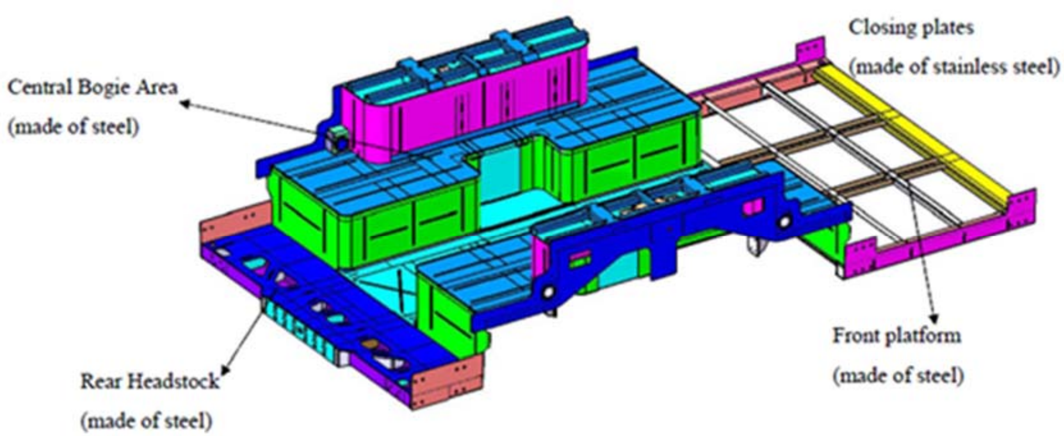


Figure 1. *Module Frame with Truck*

The underframe is a fully closed steel structure and, where indicated previously, a stainless steel closing sheet is mounted on the bottom surface, making it compliant with the 30-minute NFPA 130 test and the acoustic insulation requirements.

Suspended Module

The carbody underframe in the suspended module will be designed with the following structural elements:

- End bolsters (Headstock Side in the drawing) are attached at the ends to the articulation joints. The end bolsters are specially designed to support the loads transmitted from one module to the other (or through the lower ball joint). The frame is rigid enough to minimize its deflection under passenger loads.
- Closing plates: The bottom is covered by a stainless steel sheet that is mechanically fastened to the structure in order to meet NFPA 130.
- Central platform (Central part in the drawing) is a "metal grill" with longitudinal and transversal beams that supports the floor pan.

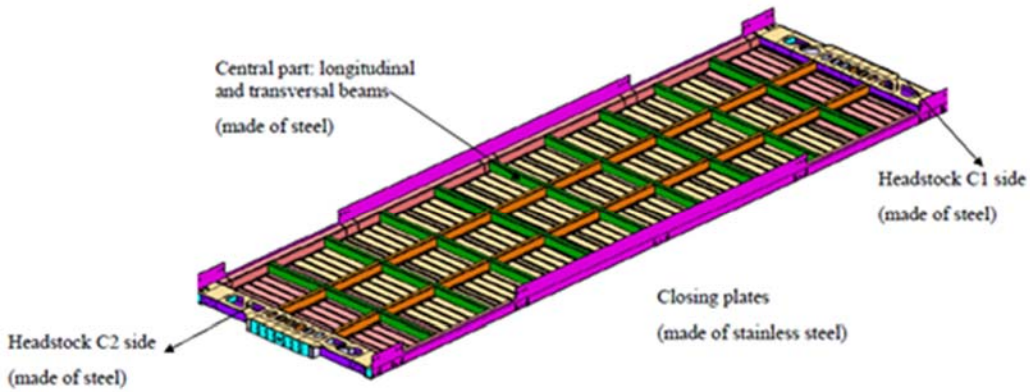


Figure 2. *Suspended Module Frame, as a reference only*

3.A.1.1.2. ROOFING

The roofs of all modules are designed using welded extruded sections of 6000 Series aluminum alloy. There are two basic parts:

- Central platform: This section is made with internally ribbed sandwich panels arranged lengthwise along the vehicle, with two main sections on the sides normally called longitudinal roof members or cant rails. The longitudinal roof members have a greater inertia which provides the roof with the necessary bending resistance to withstand the vertical load of the equipment mounted on the roof.
- End Crossbeams: The crossbeams or cross members are attached to the coupling between modules; they are specially designed to withstand the forces generated between the modules through the upper joints, which are lighter than the forces on the underframe.

The interior electrical installation, the air-conditioning conduits, and the ceiling linings are mounted under the roof. The exterior electrical installation is mounted on the roof. These assembly operations can be carried out before fitting this sub-assembly with the rest of the module components after painting.

The upper face of the roof is protected with fire/thermal insulation, making the assembly compliant with NFPA 130 for 30-minute testing requirements.

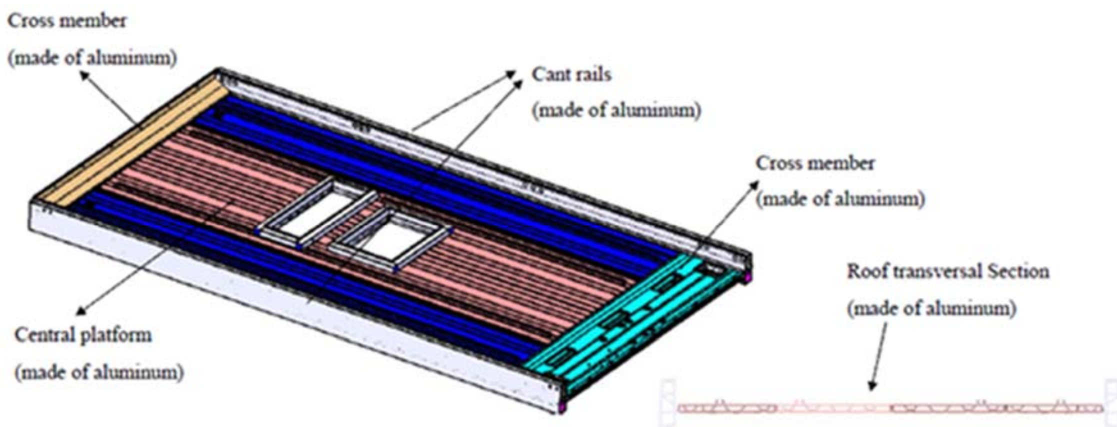


Figure 3. *Metal Roof, as a reference only*

3.A.1.1.3. SIDES

The sides consist of pillars and cross members (lined with an outer sheet) welded together to form a side sub-assembly.

The shell has openings for doors and windows: for both cases, they are framed by posts and longitudinal members to prevent deformation.

In the upper and lower side of the pillars, there are appropriate areas to join these sub-assemblies to the rest of the carbody.

In the central part of the cabin sidewall (car C1 and C2), longitudinal and vertical reinforcements have been included to join it to the underframe central truck area.

In order to improve the performance against static and fatigue loads, rounded elements have been designed in the door and window corners.

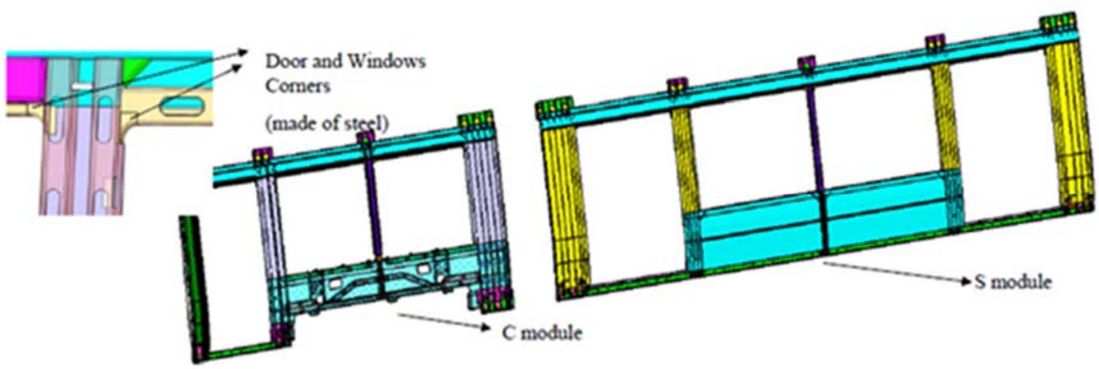


Figure 4. *Side Sub-Assemblies*

3.A.1.1.4. CAB

The cab is a self-supported module made of composite sandwich (thermoplastic foam core enclosed between fiberglass and polyester resin skins).

The core provides structural stiffness and thermal insulation, the fiberglass provides strength, and the resin acts as the bonding agent.

This material optimizes the weight of the component significantly and also allows for flexibility in designing the final shape according to the required aesthetics and styling.

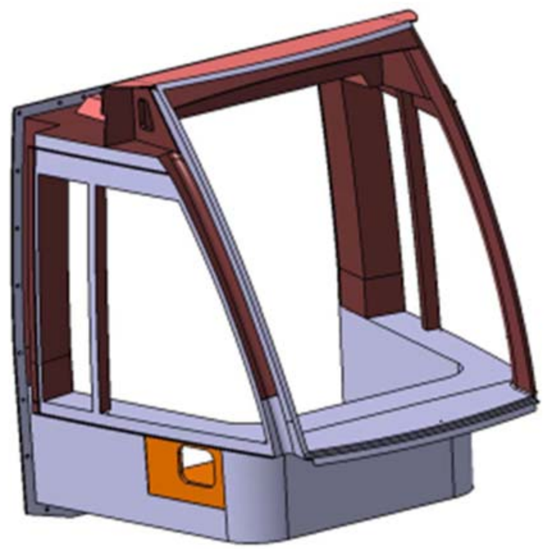


Figure 5. *Cab*

The structural design is self-supporting so that it can be hung from the end on which the module is mounted and does not have to be supported on the metal headstock on which it is located, which is subjected to major local forces.

The conceptual design of the cab is aimed at providing maximum independence so that a minimum number of assembly parts are required for the interior covering, and that a clear space is obtained to provide maximum comfort for the driver.

The driver’s desk is mounted on a ledge which is an integral part of the self-supporting core of the cab. Assembly consists of mechanical joining with screws and connecting electrical connectors. This quick and simple modular assembly makes the cab relatively easy to replace after an accident.

Additional to this self-supporting cab structure, an independent bolted steel structure is mounted in the exterior of the cab with the following purposes:

- To withstand the structural requirements in the area (compression efforts in collision and corner post, coupler anchor, anti-climbers, etc.).

- To mount the couplers and anti-climbers.
- To protect the area under the driver in compliance with NPFA 130.
- To provide protection to the cab in case of accidents.

This steel structure is covered by polyester reinforced fiberglass panels that are easy to replace if they are damaged in an accident.

Energy absorbers are mounted to two steel boxes and bolted to the headstock structure at the front of the cab. The energy absorbers are specially designed to absorb the energy of an impact between two units at a relative speed up to 15 km/h, by plastic deformation, without any other significant cab deformation. An anticlimber is also provided to avoid one unit from overriding another in case of an impact between two streetcars.

3.A.1.2. CARSHELL INTEGRATION

The modules are joined together with high-strength rivets and bolted joints.

The fasteners are sized to withstand the forces transmitted through these joints.

The gangways and Cabs are bolted to the bulkheads on either end of the Cab Module carshell, see below. The bulkheads are securely bolted to the rest of the carshell subassemblies.

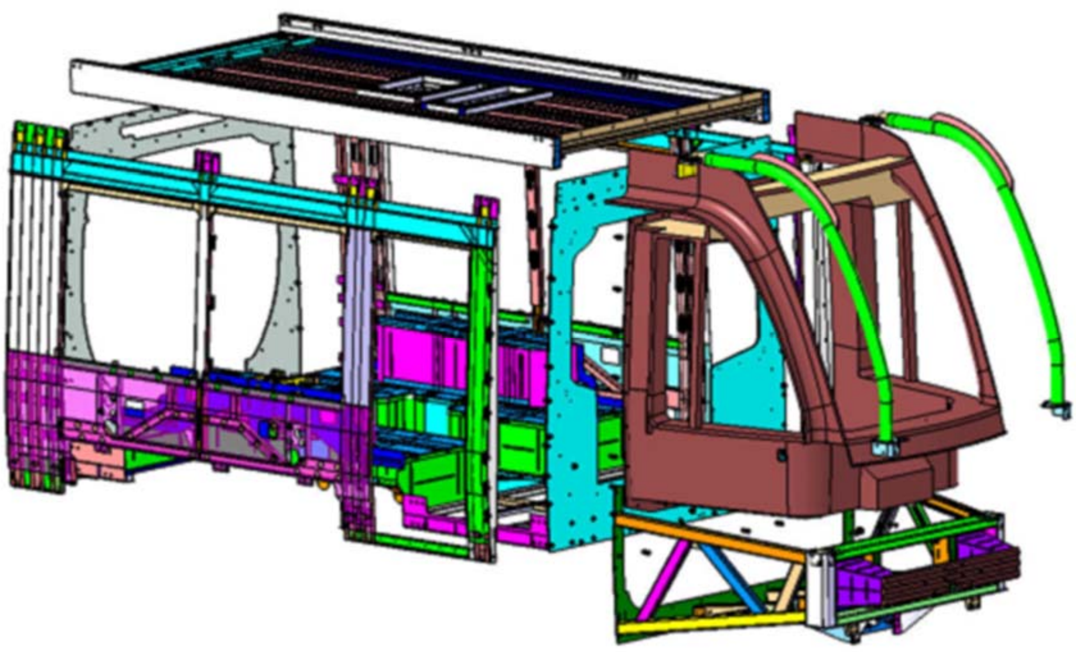


Figure 6. *Fitting of Module with Cab*

After assembling all of the subassemblies, the windows and outside linings that conceal the riveted joints are attached. In case of accidents or other damage, these parts are easily and quickly replaced with standard tools.

3.A.1.3. CRASHWORTHINESS

The crashworthiness of the structural design of the carshell has been demonstrated to comply with the requirements of EN15227:2008 for vehicles of Category C-IV (Tramway vehicles).

The Finite Element Simulations demonstrated the following:

- Energy is absorbed in a controlled manner by elements specially prepared for this purpose in the cabin end.
- Passenger and Driver survival spaces are guaranteed during the impact, according to the criteria prescribed in the standard.
- Averaged acceleration and deceleration of the vehicles during the impact are below 5 g for scenario A and 7.5g for scenario B.
- Overriding is avoided

These criteria were demonstrated in the following impact scenarios as defined in EN15227:2008:

- SCENARIO A: Impact between two identical tram units at 15 km/h.
- SCENARIO B: Impact with a road vehicle of 3 tons in weight at a 45º angle in the road.

The following elements were considered in the cab ends to provide the vehicle with the necessary energy absorption capacity:

- Coupler anchor: To join the coupler to the structure and transmit the loads from one streetcar unit to another.
- Structural components: Corner post, collision post, structural shelf, side sills, and rear sills.
- Anti-climber plate: To avoid one unit from climbing another in case of an impact between two streetcars.
- Energy absorbers: Plastic deformation modules. These are boxes, made of steel and bolted to the headstock structure, specially designed to absorb energy through plastically deforming in a controlled manner.

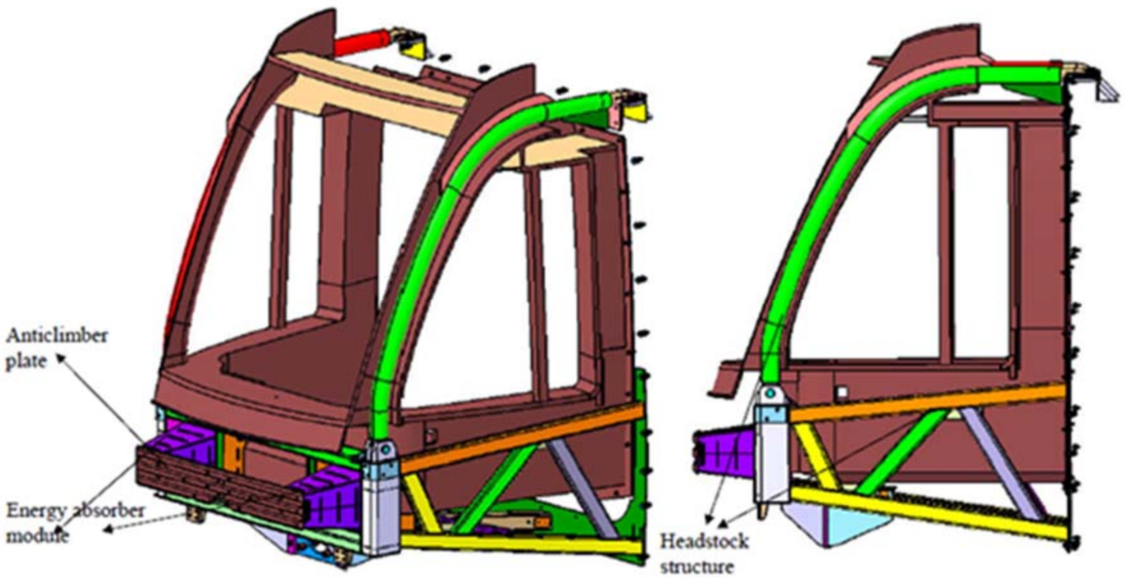


Figure 7. Details of the Front-Nose, Energy Absorbing Devices

3.A.1.4. LIFTING AND JACKING FOR DEPOT AND EMERGENCY USE

The vehicles are prepared with different points for lifting and rerailment.

These points are clearly identified in the unit according to UIC 581, and have been designed to allow for the following actions:

- Lifting of individual modules
- Lifting of complete unit with trucks suspended from the vehicle, for normal maintenance operation in depots
- Rerailment in emergency operations

3.A.1.5. WATER DRAINAGE

Rain water is evacuated from the roof through the rear end of the vehicle. Lateral evacuation is avoided in order to protect passengers passing through doorways from falling water.

The rear ends are open in order to evacuate water; however to avoid the water from falling into the gangway, collector channels are incorporated into the roof design and drained into piping that lead to the underframe.

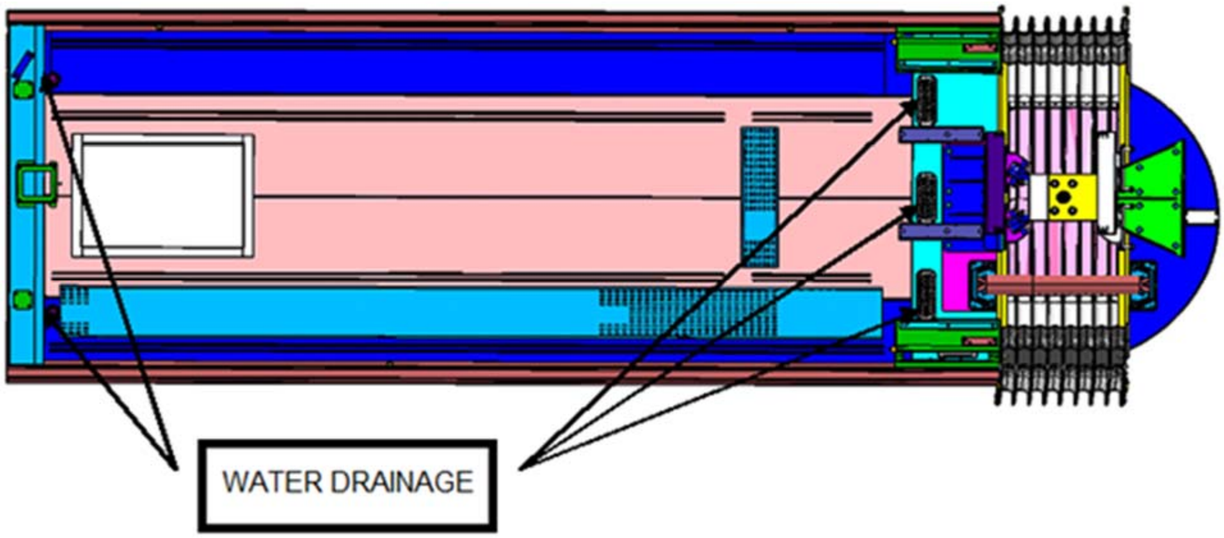


Figure 8. *Water Drainage*

3.A.1.6. ARTICULATIONS

The design of the articulated joints between the different modules is based on the following design principles:

- Capacity to articulate the unit during small radius curve negotiation.
- Structural capacity to withstand and transfer the various forces, experienced during service, between modules. These forces include:
  - The vertical load of the suspended modules on its contiguous modules.
  - The compression and traction forces resulting from:
    - Traction and braking of the vehicle
    - Exceptional towing operations
    - Accidents with other units
  - The torsional stress generated during curve negotiation of a super-elevated curve, and many other various load cases.
- Flexibility to allow curve negotiation in vertical curves, without affecting the wheel-to-rail contact on any of trucks
- Torsional flexibility to allow curve negotiation in super-elevated curves, without affecting the wheel-to-rail contact on any of trucks
- Weight reduction
- Corrosion issues

To meet these challenges, we use the following design:

- Lower articulation: A spherical joint is mounted between the underframe crossbeams. This joint allows relative rotation between modules on any of the three axes, and at the same time is capable of transmitting the vertical and compressive forces, as any relative movement is restricted. The lower articulation is located inside the gangway bellows and therefore is protected from rain water.

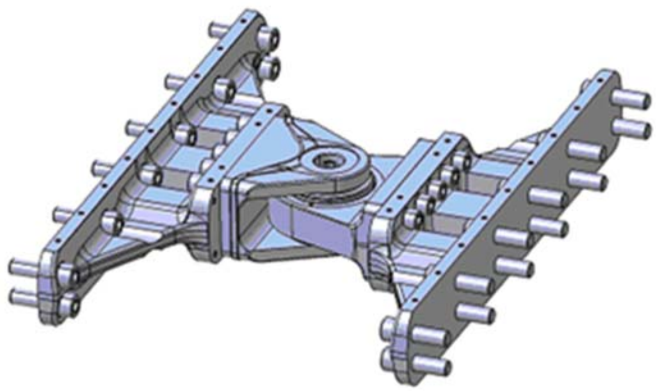


Figure 9. *Lower Articulation*

- Upper articulation: The upper articulation joint joins the modules at the roof to provide sufficient flexibility for curve negotiation in super-elevated or vertical curves, aiding in the transmission of bending moments and twisting torques. This allows us to build a lighter module.

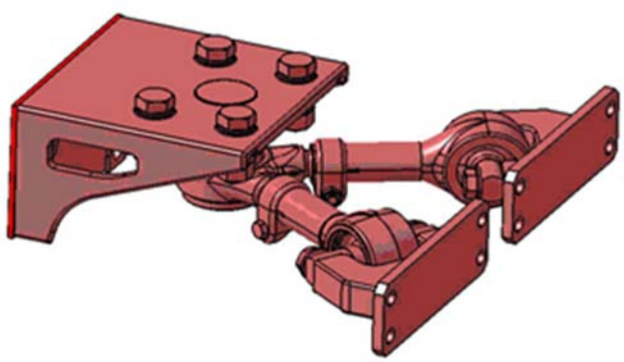


Figure 10. *Upper Articulation*

Because the upper articulation joints are located on the vehicle exterior of the vehicle and on the roof, they are directly exposed to rain, snow and atmospheric conditions. To account for the environmental conditions, the metal parts of the articulation joints use galvanic protection and have layers of protective paint. And the ball joints are covered by protective rubber boots.

Additionally, the junction of the modules is covered by a gangway, to provide a comfortable and safe space for passengers, that at the same time is flexible enough to accommodate the relative movements between modules.

The following figure shows the location of the elements between modules, including the bellows.

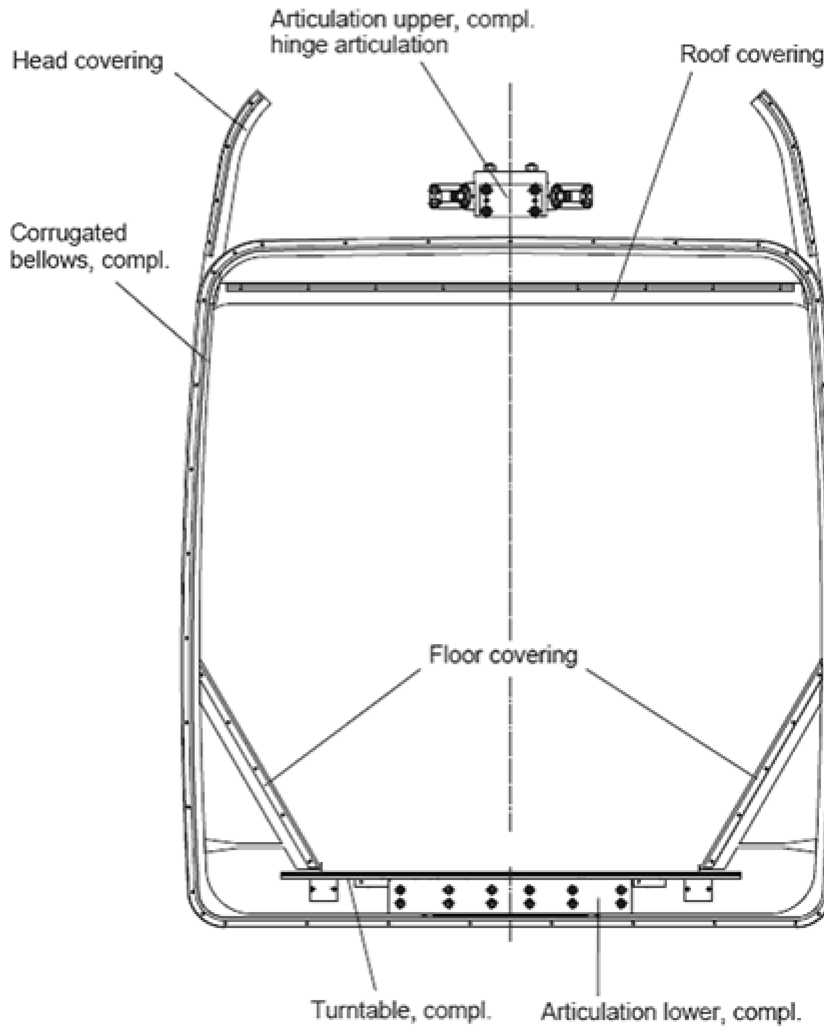


Figure 11. *Gangway*

Wiring between modules is routed above the roof articulation joints inside flexible conduits. The design of the inter-module solution is durable and able to deal with the combined horizontal and vertical movement associated with a regular operational service life without causing damage or defects.

3.A.1.7. PEDESTRIAN AND COLLISION PROTECTION

The streetcar is continuously skirted along the sides and front, protecting pedestrians from the cavities found on traditional railway vehicles, such as the coupler housing on the front end, and the truck housing on the sides.

Both elements are covered by skirts that provide the accessibility needed for maintenance while protecting pedestrians from directly hitting the coupler or the truck, which are intrinsically dangerous due to their geometry, material, and functionality.

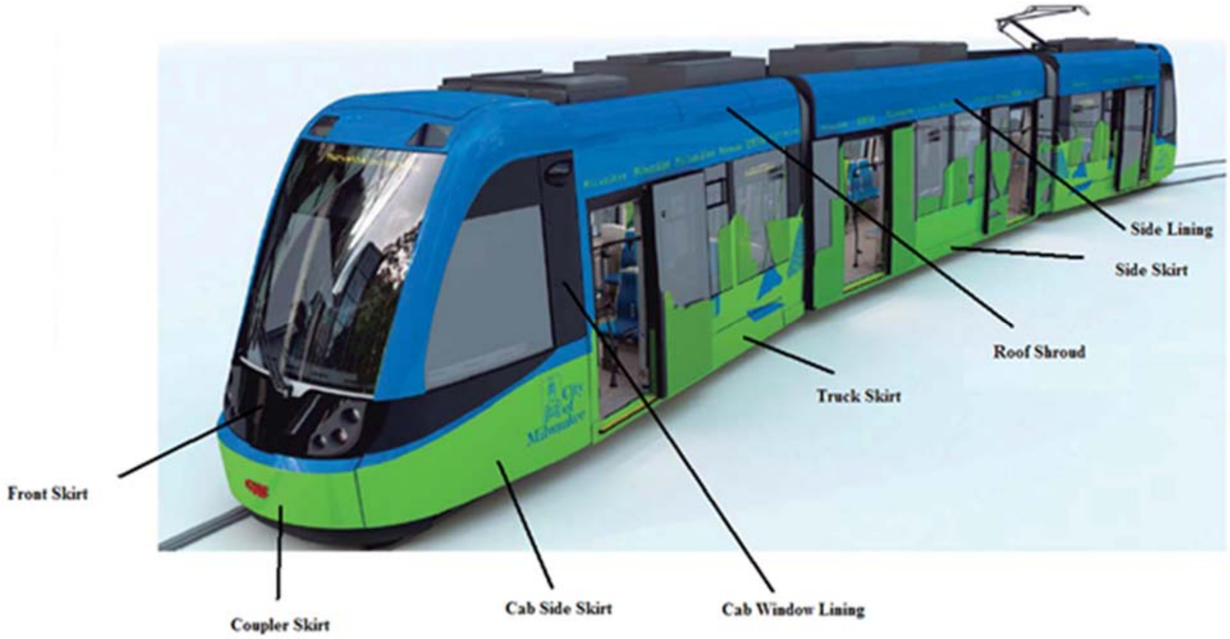


Figure 12. *Continuously Skirted Streetcar (image for reference only)*

Additionally, the front end is designed to deflect any impacting obstacles towards the side, due to its rounded shape.

The proposed vehicle does not include the energy absorbing bumper requested optionally in section 3.4.2.2 of the Technical Specification.

3.A.2. INTERIOR AND EXTERIOR APPOINTMENTS

3.A.2.1. GENERAL

The proposed streetcar is designed to transport all types of people, including children, passengers with luggage, mobility impaired people, blind or deaf people, and handicapped persons, including non-ambulatory persons in wheelchairs. The dimensions of the standard passenger are characterized by the anthropometric models of the male and female of the local population.

The following figures show both the exterior design proposal and the overall passenger compartment design. Please refer to Appendix 1.1 for further artist renderings, where various proposals are submitted for the interior design and the exterior lining.

Figure 13. *Example of one of the exterior lining proposals*

Figure 14. *Passenger Compartment Design (car with cab)*

All the materials used by CAF will be robust and strong enough to withstand demanding long-term use. They can be cleaned or replaced easily. Dirt traps are avoided. The following chapters describe the different elements of the passenger compartment.

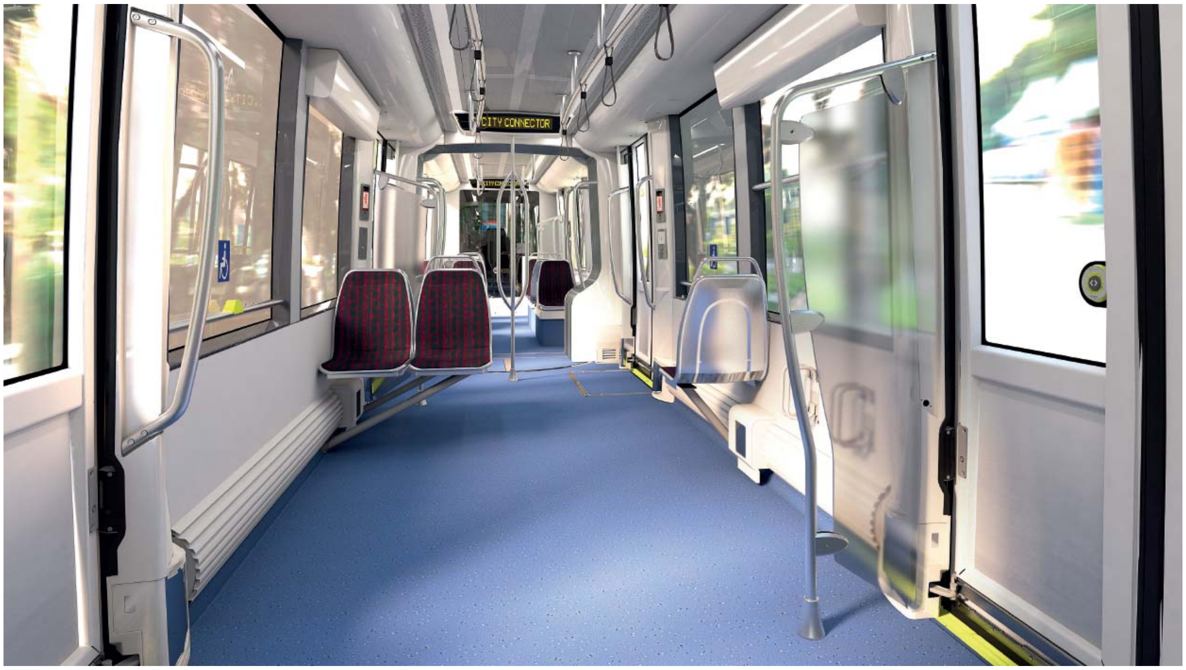


Figure 15. Passenger Compartment Design (intermediate car)

3.A.2.2. PASSENGER ACCESS

Each side of the unit consists of a single leaf door near the cab in the driving direction, and two double-leaf doors on the S1 module.

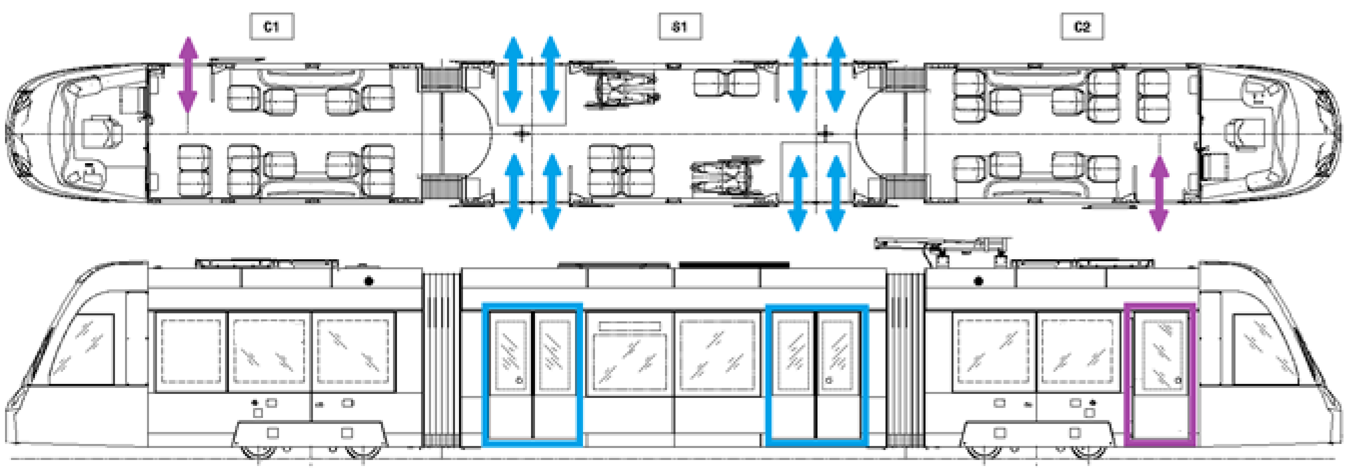


Figure 16. Position of the Single- and Double-leaf Doors on the Streetcar

A 100% low floor streetcar is proposed, with the floor level nominally 14 3/8″ (365 mm) above top of rail along the entire length of the train, including the door access area. This minimizes the possibility of passengers tripping. The streetcar platform was designed to keep passenger boarding times as short as possible. To this end, the following measures were adopted:

- Clear signaling of entry and exit on the lower part of the door with a yellow strip to signal vehicle exits.

- The distance between the doors shall be kept as uniform as possible for this type of vehicle, favoring uniform access along the entire vehicle.
- Streetcar vestibule access is totally unobstructed to promote a rapid flow of passenger traffic in both access directions.

3.A.2.3. WINDOWS

The proposed streetcar provides a large glazed area on the sidewalls, with a high percentage of the vehicle sides made up of windows and door glazing, giving an enhanced sensation of interior space through the entry of natural light from the exterior. These wide glazing areas allow the passengers to enjoy their journey, with a wide field of view both for seated and standing passengers, to allow a clear view of the information displayed in stations.

For aesthetic purposes, the outside of the windows is designed such that the top line coincides with the top part of the access doors, achieving a single line along the entire streetcar.

Fixed windows are fitted on the sidewalls of the passenger area of the unit.

The windows are formed by a single-glazed, fixed type, laminated glass bonded to the carbody by means of a flexible adhesive. This glazing will be mounted in such a way that it is flush with the exterior surface of the carbody. The mounted windows are hermetically sealed along their entire perimeter by means of a flexible polyurethane sealant in order to avoid the entry of air or water in normal operating conditions or during cleaning. The products used to seal the glass and bond it to the carbody are compatible.

WINDOW	DESCRIPTION
Glass panel	Laminated glass
Protective films	Interior anti-scratch and graffiti film
Light transmission	Approx. 44%
Solar factor	Approx. 51%
Window thickness	Approx. 1/4 in (6.35 mm)

Table 1. *Passenger window characteristics*

All passenger compartment windows are protected with an optically clear, distortion-free anti-scratch film on the interior facing surface. The anti-scratch film is maintenance-free, and only needs to be removed or replaced if it is scratched (without removing the glass from the window frame). The film protects the windows from graffiti (which could be removed with non-volatile liquids). The windows have been designed to be swiftly replaced via mechanical means should they be broken, in order to minimize down time. Using appropriate tools, the window replacement, including bonding time, does not exceed eight hours (two people) from the time work begins to availability for revenue service.

3.A.2.4. PASSENGER SEATS

The proposed seat provides optimum comfort, and has been specifically designed for daily use on urban and streetcar transport. The seats are modular, individual, interchangeable, vandal-proof, and

lightweight. Their modular construction provides for a wide range of options. The proposed seat width is 17.5" (445 mm), in line with several light rail vehicles in the US. By means of spacers, the 18″ (460 mm) width defined in the technical specifications can be achieved, but this would lead to a narrower corridor. Therefore, this is not recommended.

Figure 17. *Passenger Seats (image for reference only)*

The seats consist of a single sturdy self-supporting frame, with an insert. They are completely free of sharp angles and corners and prevent fatigue from vibration. They are easy to clean. The seat upholstery is sufficiently durable to withstand heavy use on a modern streetcar with frequent passenger use for short journey durations. In addition, the seats and inserts can be easily replaced in the event of damage or vandalism, but are sufficiently secured to discourage removal by unauthorized persons. The seat design is such that it restricts the placing of objects, such as sharp objects/trash, down the sides or between seats.

On the cab modules, the seats are mounted over the truck boxes. The seats on the aisle side include a handrail, at the top, to be used by standing passengers.

Figure 18. *Seats Mounted on Cab Modules*

Fixed seats assembled in cantilever are provided in the intermediate car. This makes cleaning of the flooring easier.

Figure 19. *Seats in the intermediate car*

A specific area is reserved for bicycle users, where bicycles can be stored vertically.

Figure 20. Bicycle Storage on the Zaragoza streetcar

3.A.2.5. MOBILITY IMPAIRED ACCOMODATIONS

The vehicle accommodates two wheelchair spaces, with a minimum clear floor space of 48" (1220 mm) by 30" (762 mm), located in the suspended module.

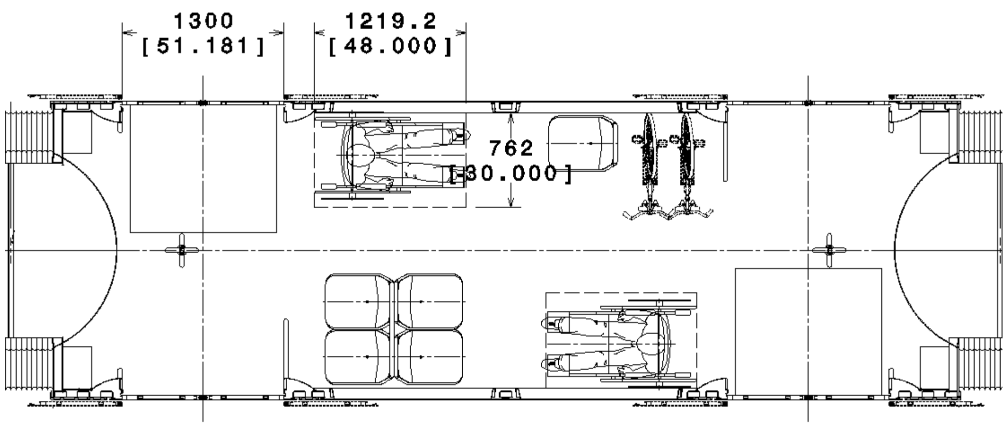


Figure 21. Wheelchair areas in the intermediate car

Accessibility for mobility impaired persons in wheelchairs is provided through two doors and their corresponding automatic ramps, one on each side of the vehicle.

Figure 22. *One of the two ADA locations on the intermediate car*

The wheelchair space is free of vertical stanchions and other obstructions. Passengers will be able to walk on and off the vehicle without being impeded by either the wheelchair and its restraint, or the retracted restraint when a wheelchair is not on-board. This space is also designed to accommodate strollers.

Figure 23. *Mobility Impaired Accommodations Area*

The wheelchair space is clearly indicated via signage, according to ADA requirements. Suitable graphics are provided at each wheelchair area to indicate that the primary use of the area is for wheelchairs.

The wheelchair space incorporates one horizontal handrail. Additionally, the ADA locations have stop request buttons.

3.A.2.6. STANCHIONS, HANDRAILS AND WINDSCREENS

The vehicle is equipped with all the support points and holdings required to promote passenger stay, access, and circulation along the streetcar.

The stanchions and hand rails are stainless steel.

The handrails have a 1.38" (35 mm) diameter circular cross-section that is easily gripped.

All the handrails on the streetcar are sturdily fastened to the car structure to prevent vandalism. These robust connections also mitigate vibration and mis-adjustment of the rails during the streetcar's operating life.

Figure 24. *Layout of the Stanchions, Handrails and Wind Screens of the Cab Module*

3.A.2.7. INTERIOR LININGS

Please refer to section 3.F within this document for the proposed interior linings and trim materials.

3.B. DESIGN LOAD AND PREVIOUS EXPERIENCE

3.B.1. CARBODY STRUCTURAL DESIGN LOAD

For further information regarding the carbody structural design load please refer to Appendix 3.1 Load Cases, where a description of the design loads can be found.

3.B.2. PREVIOUS EXPERIENCE

The proposed vehicle is based on Cincinnati Streetcar and Kansas City Streetcar. The following table summarizes service history.

Project	Number of vehicles	Time in use	Agency / Entity
Kansas City Streetcar	4	Since May 2016	City of Kansas City
Cincinnati Streetcar	5	Since September 2016	City of Cincinnati
Urbos 100 Family	More than 200	Since 2010	Upon request

In order to make the existing streetcars compatible with SDOT's existing fleet, the height of the anticlimber has been modified.

3.C. FLOORING CONFIGURATION

The proposed streetcar has a 100% low floor throughout the passenger area, even in the seating areas. The only step in the streetcar is in the doorway to the operator cab. This step does not intrude into the passenger area.

The floor consists of composite panels faced with polyester resin, guaranteeing a high degree of stability and sound insulation. The floor panels will be attached to the structural beams with screws and supported by elastic adhesive and phenolic strips riveted along the structure beams.

Metallic shims may be used to achieve the floor height.

The top surface of the floor panels is, as appropriate, covered with a 0.125 in (3 mm) thick rubber flooring, bonded with a bi-component (2C) adhesive. This adhesive guarantees complete leak tightness between the floor linings and the composite panels.

Where possible, for example under windows in the suspended module, the floor finish curls up the side walls, providing a leak tight "bath-tub" effect. Where this type of solution cannot be provided, the flooring is sealed against the sidewall. In door areas, the flooring is covered by the door thresholds, sealed where the thresholds meet the flooring.

The proposed floor has the following features:

- Resistance to heat and against abrupt temperature changes.
- Good thermal and acoustical insulation.
- Resistance to vibrations, excellent flexibility, and folding features.
- Resistance against cigarette burns.
- Fire and smoke behavior in compliance with the NFPA 130 standard.
- Extremely tough.
- Resistant to punching.
- Abrasion resistant.
- Maintains color stability in intense sunlight.
- Easy to clean.
- Resistant to chemical agents.

3.D. INTERIOR STEP ARRANGEMENT

The floor of the streetcar is flat and low from end to end of the passenger compartment, with neither steps nor ramps along the entire length. This enables one of the best interior passenger flows in the US market. Other streetcars in the market have interior steps which notably slow down the passenger flow and increase dwell times in stations.

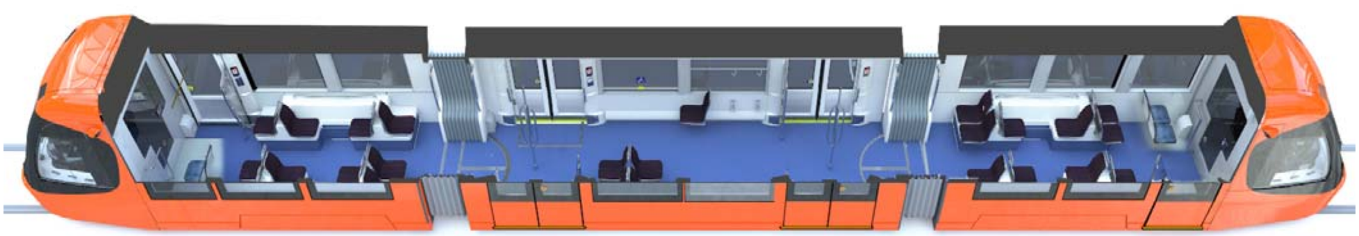


Figure 25. *Passenger compartment rendering: 100% flat and low floor*

Additionally, the number of doors per side and the large passenger access areas, combined with unobstructed vestibules and the low floor, enable optimal passenger boarding and alighting times. All this provides the operator with an efficient and agile rolling stock fleet, which translates directly into high passenger satisfaction rates.

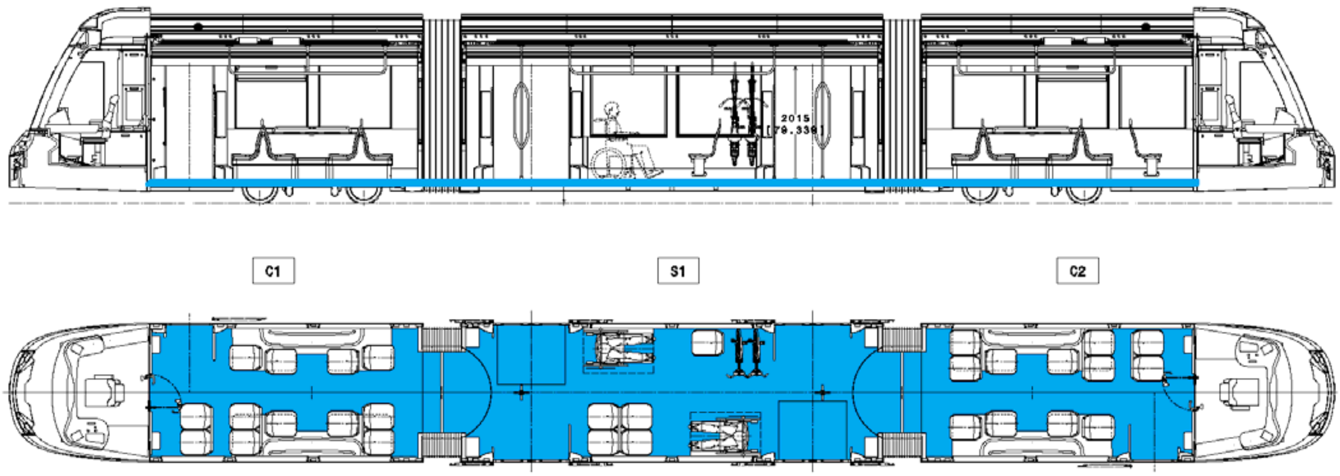


Figure 26. *Passenger compartment overview: 100% flat and low floor*

3.E. DESCRIPTIONS AND LOCATIONS OF ALL EQUIPMENT LOCKERS AND BOXES IN THE INTERIOR

Various pieces of equipment are installed in the interior of the vehicle. In the passenger compartment, above the windows, in the upper interior lining:

- Circuit Breakers and contactors panel
- Relays panel
- Switches panel

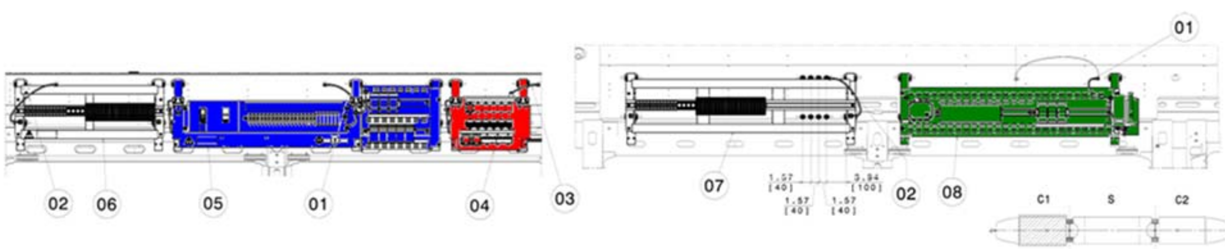


Figure 27. *Circuit Breakers, Relays panel, and Switches*

Please refer to drawing Q.00.238.74.001 for the interior equipment arrangement of the passengers' compartment, included within Appendix 1.2.

3.E.1. EQUIPMENT LOCKERS AND BOXES IN THE INTERIOR

The low voltage electrical lockers are installed on both sides of the cab interior.

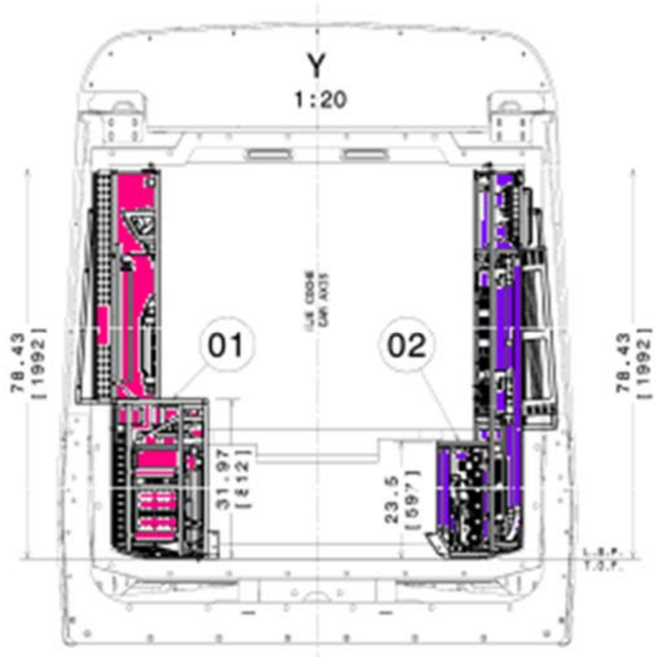


Figure 28. *Cab Electric Lockers*

Electrical Lockers are composed of:

- Relays
- Circuit Breakers
- Contactors
- Different Equipment racks (TWC, PIS, TCMS, etc.)

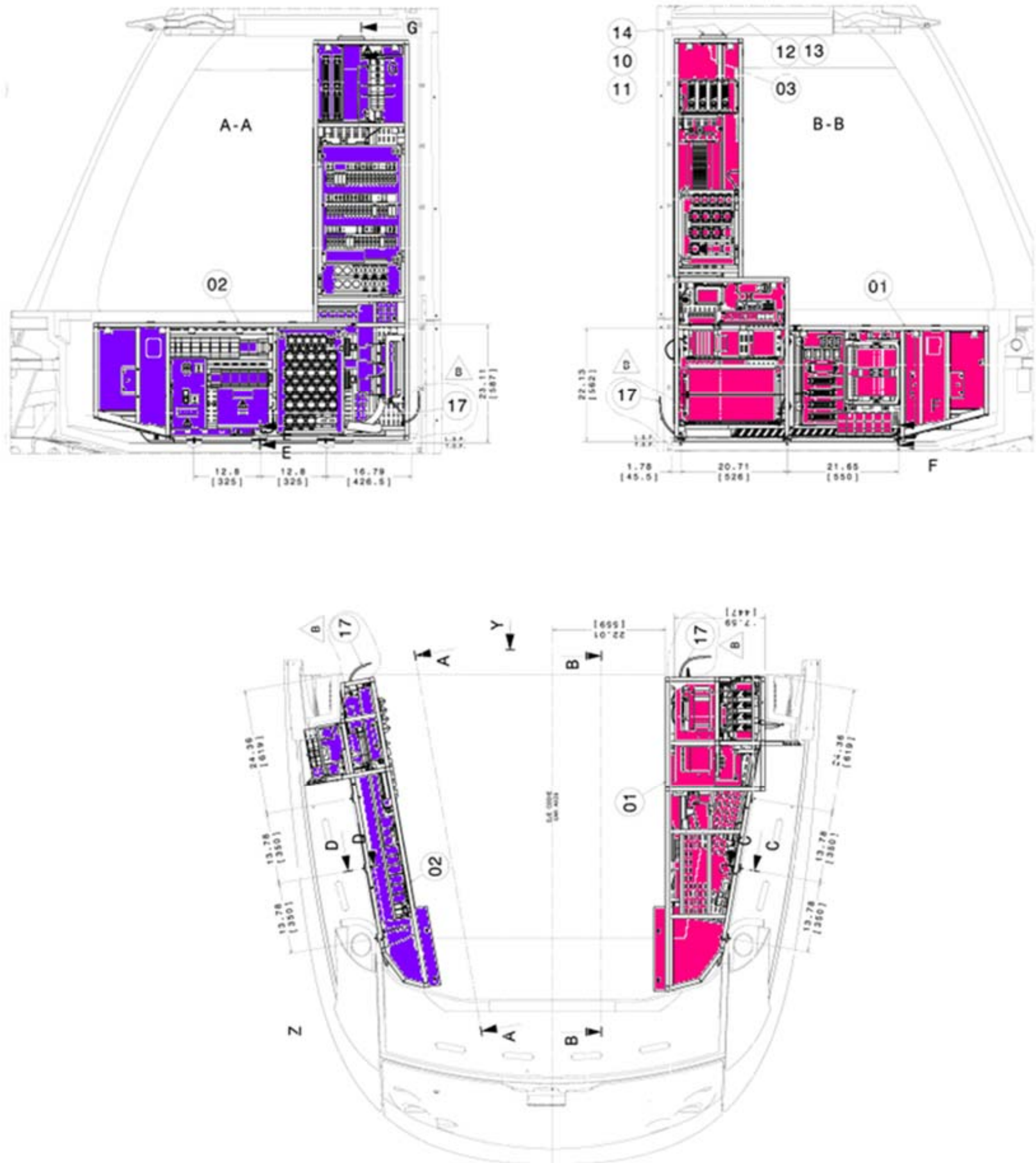


Figure 29. *Different views of the Electric Lockers*

3.F. PROPOSED INTERIOR LINING AND TRIM MATERIALS

The following paragraphs show the proposed solution for the interior lining and trim materials.

3.F.1. FLOORING

Please refer to section 3.C within this document for the description of the proposed flooring.

3.F.2. WALLS

The wall covering is made with small panels to facilitate mounting and removal. The panel mounting system has been designed to conceal rivets and screw heads.

The following items are mounted in an overlapping fashion to avoid any possible grooves, which result in the accumulation of paper or trash left by passengers.

- Fiberglass reinforced polyester door pillar linings. These items conceal the door supports located on side walls. The intercom and the inside door release device are located on these items. These items include a gel-coat finish with anti-graffiti protection paint.
- The lower part of the door pillar linings are removable to provide access to the door mechanism supports. These are fiberglass-reinforced polyester items which can be mounted and removed both swiftly and safely.
- Covers between windows, pillars, and linings under windows. These are 0.12" (3 mm) thick HPL (High Pressure Laminate) items, with the interior zone reinforced with aluminum sections.
- Truck box linings consist of fiberglass-reinforced polyester parts around the truck suspension area. These items include a gel-coat finish with anti-graffiti protection paint.

The properties of these items are as follows:

- HPL and polyester parts have high resistance to scratches caused by passengers.
- Mass coloring capacity on polyester parts to conceal scratches and to avoid repainting.
- Anti-graffiti protection.
- They do not sink.
- The items are attached so as to prevent vibration and clattering.
- The items are securely and positively attached for a long service life.

3.F.3. CEILINGS

The ceiling lining consists of manageable modules which are fixed and fastened such that there is no clattering. They do not sink easily and will not become detached in the long term.

The central section of the ceilings, together with the roof, provides the ducting for the HVAC roof mounted units.

This air ducts are made up of the following items:

- An extruded aluminum section is fitted on each side of the ceiling to which the light fixtures are fastened. This section is mechanically fastened to the carbody roof. Apart from being a structural item that the other ceiling items are mounted to, this also seals the sides of the air duct. 0.059″ (1.5 mm) aluminum central ceiling, mechanically fastened to the extruded aluminum sections of the light fixtures. Sound and heat insulation is bonded to the inside part

of the ceiling, with one surface protected with an aluminum web. The exposed part of the ceiling is painted in the interior color chosen.

- The light fixtures are mechanically attached to the aluminum section. The light fixtures consist of an aluminum body with a polycarbonate lampshade cover, and aluminum flange plates on which the air conditioning outlet holes are die cast. These aluminum parts are painted in the interior color chosen.
- Finally, the interior surface of the roof is made up of fiberglass insulation and covered with an aluminum sheet. Once installed, the insulation is enclosed between the aluminum bent plate and the roof. This solution provides heat insulation, reduces hot and/or cold air loss to the outside, as well as increases sound absorption in the top area of the ceiling.

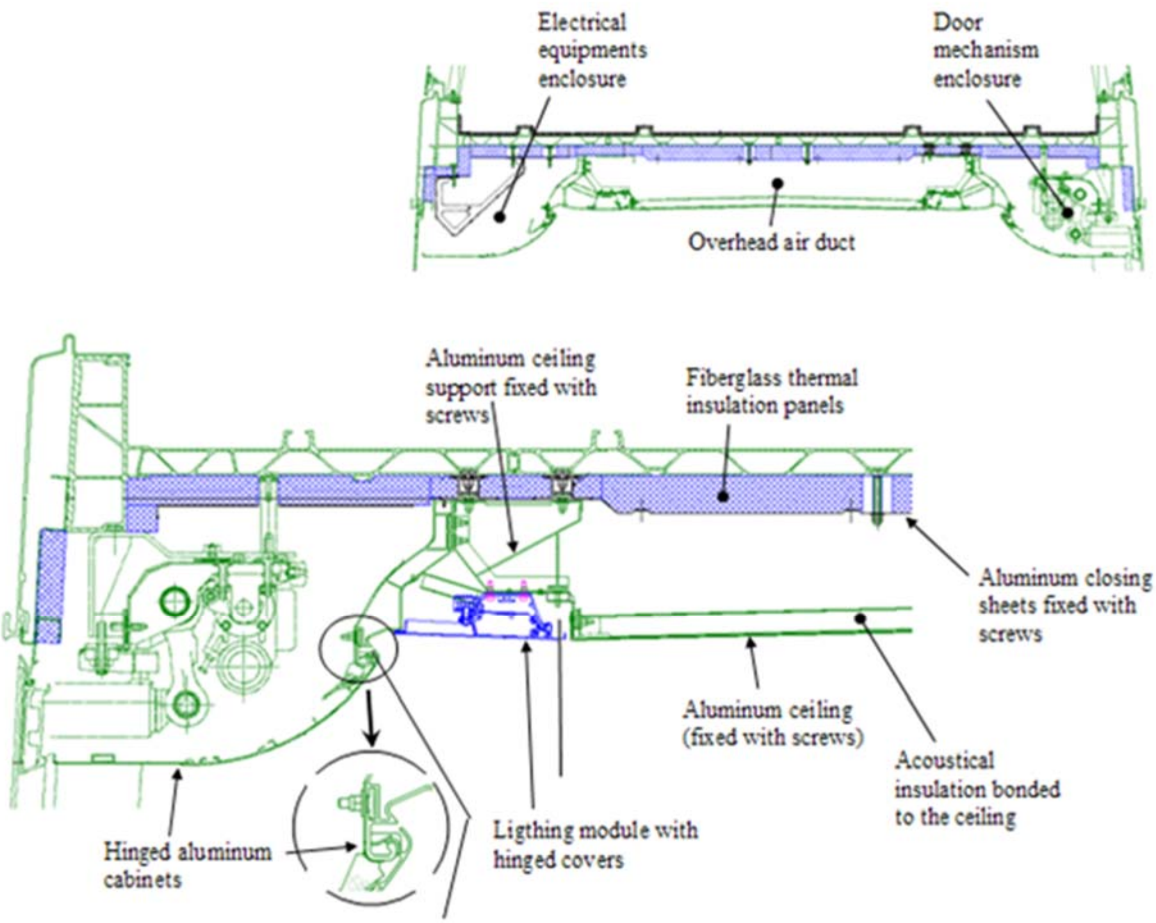


Figure 30. *Cross Section Showing the Ceiling Items*

3.F.4. INSULATION AND INTERIOR PANELS

3.F.4.1. THERMAL AND NOISE INSULATION

Due to special insulation requirements and external weather conditions, special care will be paid to the insulation installed in the vehicles and the choice of insulating materials. The material composition will provide appropriate insulating characteristics and allow proper drainage of inside moisture, which is

caused by condensation on the inner part of the metallic carbody. It will also provide proper ventilation of the internal insulation materials.

Proposed thermal insulation:

- Fiberglass with aluminum foil for the roof, sides, and truck box insulation, of different densities and thicknesses, depending on the location.

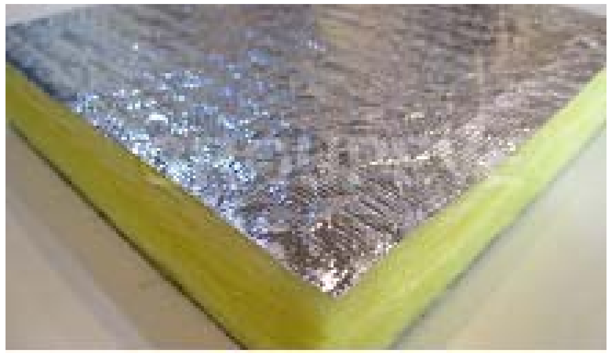


Figure 31. *Fiberglass with aluminum foil*

- Rockwool for the floor, being the main section as shown in figure 15

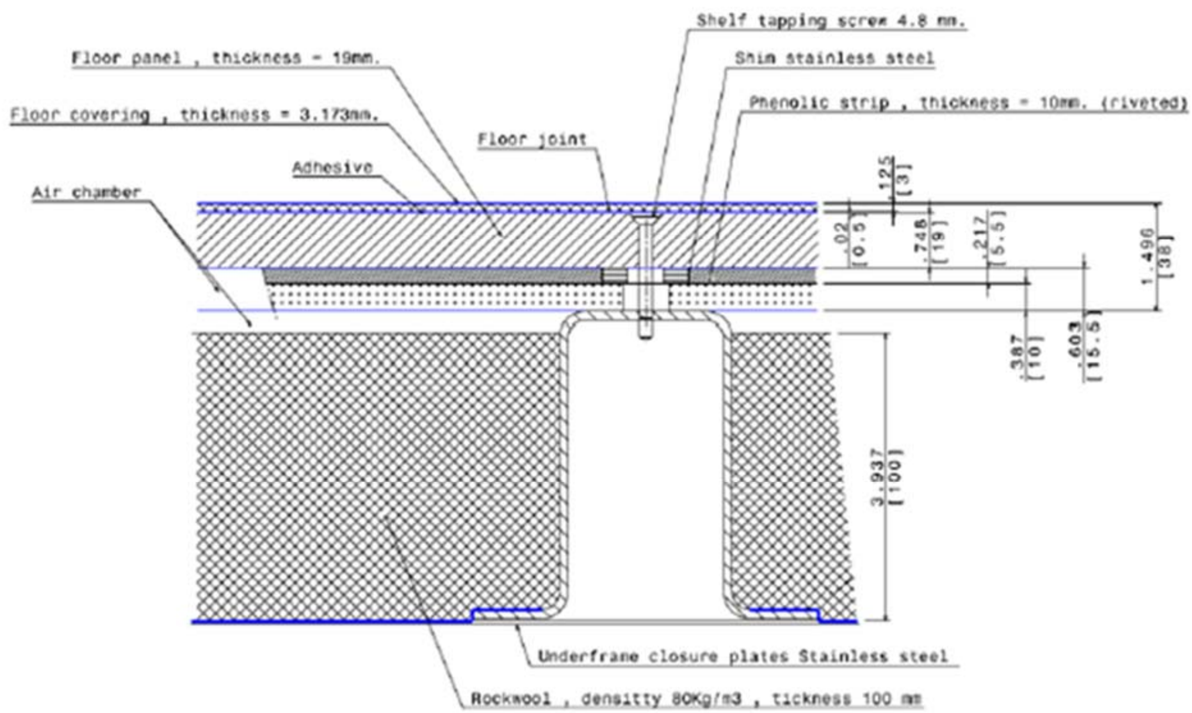


Figure 32. *Flooring Insulation*

In areas where there is not enough space for the complete insulation package, the layers of insulation layers are substituted by a board of NH/Armaflex, a flexible elastomeric closed cell structure. This material is an excellent vapor barrier and has excellent thermal insulation properties.

3.F.4.2. FIRE INSULATION

The floor design described above meets the NFPA 130 fire requirements for 30 minute testing:

- 0.125" (3 mm) rubber flooring glued to the panel boards.
- 0.748" (19 mm) composite floor panel boards screwed to the frame. The zones where the board is supported are protected with phenolic strips.
- 3.937" (100 mm) rock wool insulation panels of 80 kg/m3, between the steel structural beams and the underframe stainless steel closure plates riveted 0.024" (0.6 mm).

The roof design also meets the fire requirements per NFPA 130 for 30 minute testing. A stainless steel roof pan of 0.6 mm (0.024 in) is provided over the aluminum roof throughout the length of the car. The space between the roof pan and floor structure are filled with Microtherm insulation, 10 mm (0.39 in) thick.

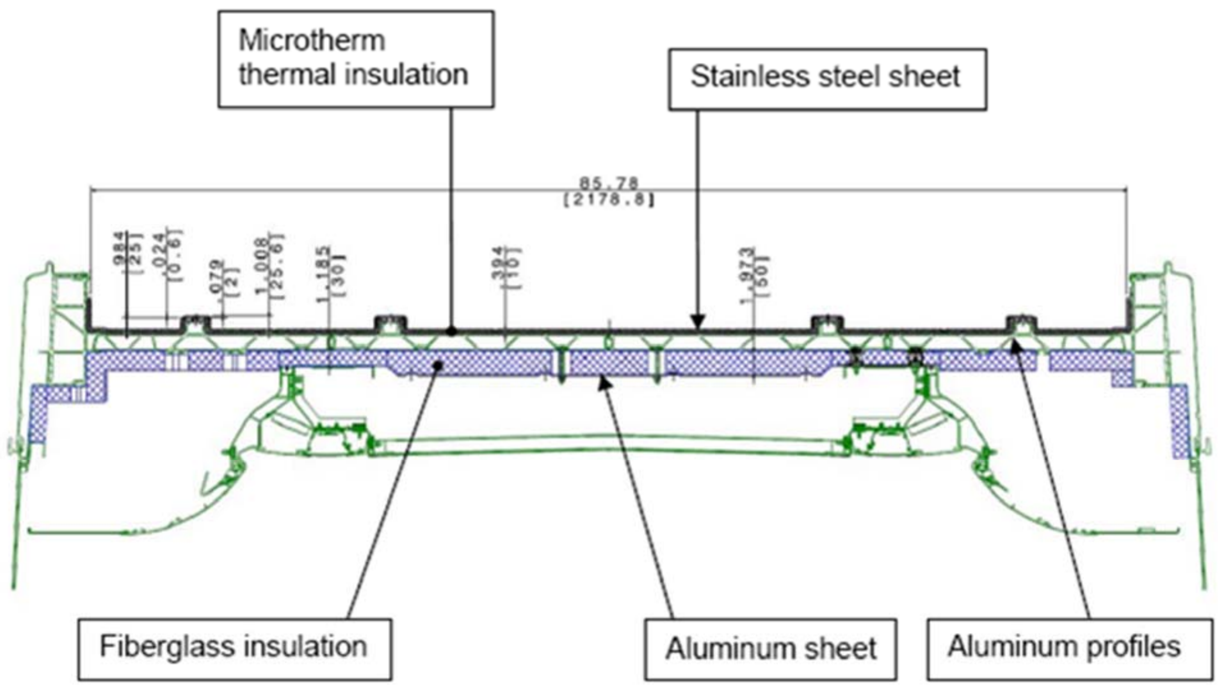


Figure 33. *Roof Insulation*

Microtherm material has a very low thermal conductivity at very high temperatures, which makes it optimal for fire barrier applications where low thermal transmission performances are required in combination with light weight and compactness.

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Sub-Part A – VEHICLE DESCRIPTION

Sub-Part A – VEHICLE DESCRIPTION

SECTION 4 COUPLER REQUIREMENTS

4.A. COUPLER ASSEMBLY SYSTEM DESCRIPTION

The ends of the proposed streetcar feature manually operated foldable couplers (Albert-type) which enable mechanical coupling with another vehicle, only for rescue operations.

When not in use, the coupler is folded and stored in the carbody underframe, behind a moveable skirt. During towing operation, an electrical cable with connectors on both ends is used to convey the necessary signals. This cable is housed in one of the side compartments of the suspended (center) module.

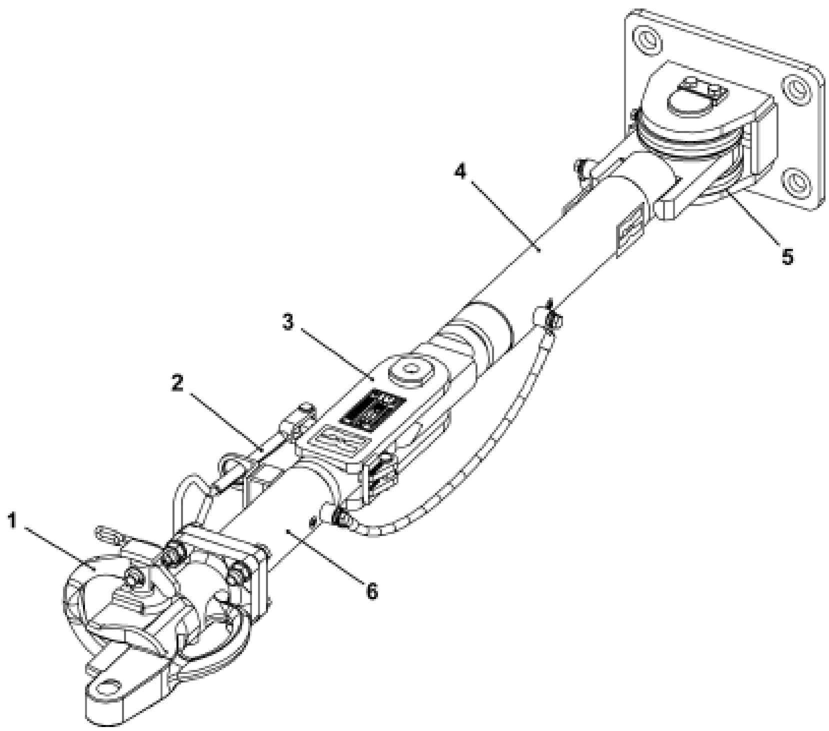

Figure 1. *Proposed coupler*

4.A.1. COUPLER MAIN COMPONENTS

Item	Description	Item	Description
1	Coupler head	4	Draft bar
2	Release handle	5	Bearing bracket
3	Folding joint	6	Coupler bar

The forces between two coupled vehicles are transmitted from the coupling head (1, Figure 1), through the coupler bar (6) and draft bar (4) to the bearing bracket (5) which is attached to the module underframe.

4.A.2. TECHNICAL CHARACTERISTICS

- Total weight...165.35 lbs.
- Maximum horizontal pivoting angle...±50º
- Maximum traction force..200 kN
- Distance coupling surface – folding joint.. 25.23 in
- Distance folding joint – pivot .... 28.15 in
- Distance folding pivot – mounting Surface.. 3.74 in

The Albert-type coupler is mounted at a height of 400 mm (15.75 in). An adaptor will be provided together with the coupler in order to ensure compatibility with the existing vehicles (both regarding the coupler height differences and the coupler type itself).

4.B. ASSEMBLY LEVEL DRAWINGS

Please refer to drawing Q.00.238.18.001.

4.C. COLLISION BEHAVIOR OF THE COUPLER

The Albert coupler used on the proposed vehicle does not absorb energy when coupling since it is designed to be operated manually. Please refer to Sub-Part A Vehicle Description/3 Carbody Requirements for a description of the vehicle's crashworthiness.

4.D. RETAINING HOOK

When units are not coupled, the coupler is folded and fixed to the underframe of the module by pulling on the release handle (2, Figure 1) to unlock the folding joint (3). When the coupler is folded it is secured to the vehicle by means of a retaining hook.

The retaining hook keeps the coupler folded under the carbody frame behind the flap door (shroud) at the front part of the vehicle.

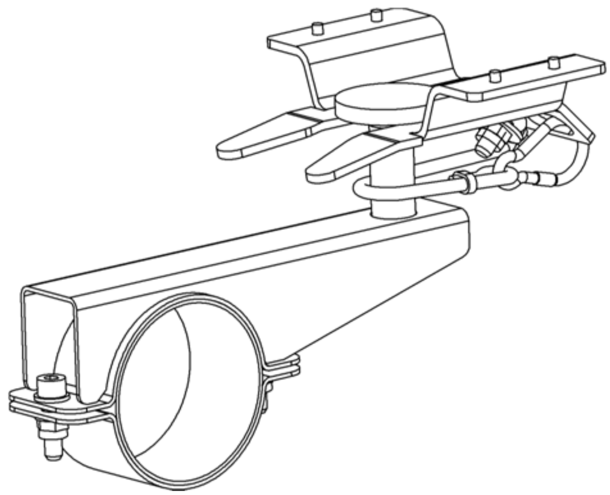

Figure 2. *Retaining hook*

4.E. COUPLER SHROUD

The cab cars have a polyester front skirt mounted below the front end. The skirt is hinged to provide access to the coupler which is retracted behind it. The opening mechanism consists of two springs joined to two tie bars and two levers with which the skirt can be opened, moving them outwards and then upwards.

Opening the skirt is accomplished by using a double brake wrench to turn the four locking devices, two on the right and two on the left. The outer surface of the skirt has two notches to close it by hand with ease.

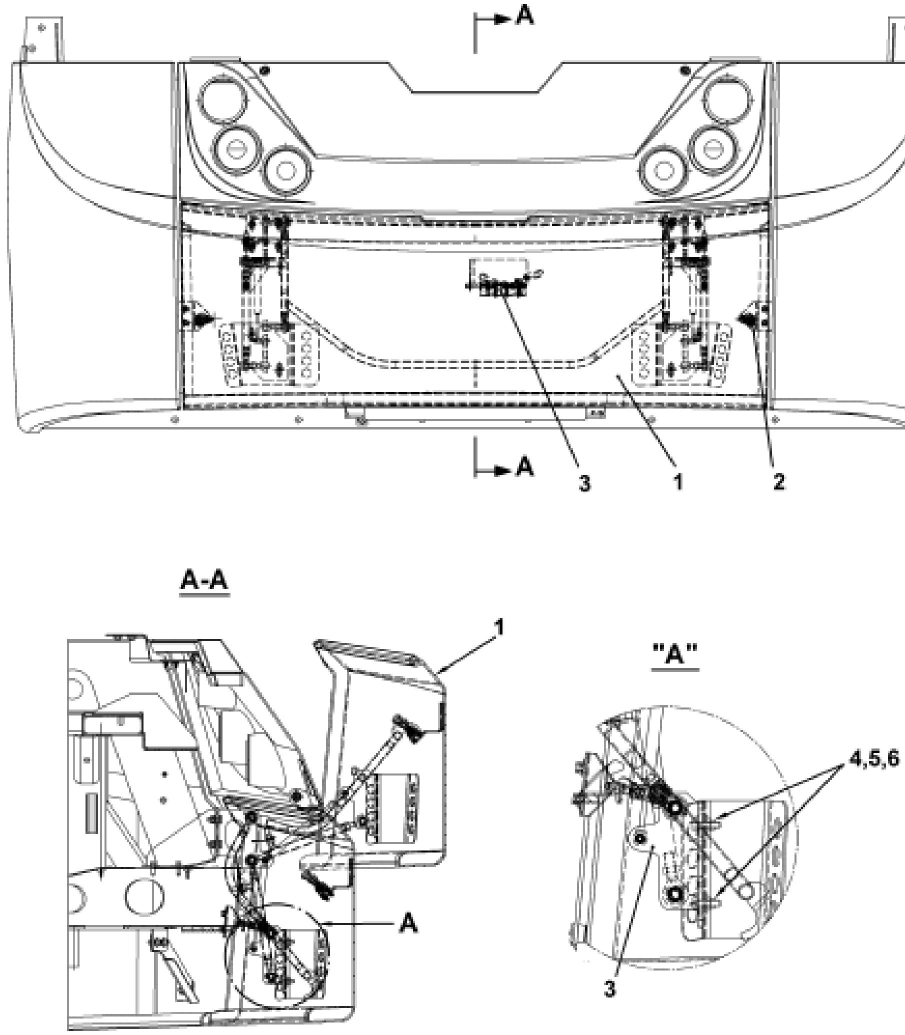

Figure 3. Coupler fairing

Item	Description	Item	Description
1	Coupler fairing	4	Screws
2	Locks	5	Flat washers
3	Opening mechanism	6	Lock nuts

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Sub-Part A – VEHICLE DESCRIPTION

SECTION 5 OPERATOR´S CAB REQUIREMENTS

5.A. OPERATOR’S CAB SYSTEM DESCRIPTION

5.A.1. GENERAL

The proposed streetcar vehicle is bidirectional and has a full-width operator’s cab on each end. The cab houses the equipment required to operate and control the streetcar.

The cab interior is designed so that when the operators adjust their seat for optimal comfort, visibility and vehicle operation, all of the controls are easily accessible. The design also takes into account maintenance accessibility to facilitate easy access and repair. The operating station is centered with respect to the longitudinal axis of the vehicle, ensuring comfortable operation and optimum visibility from the seated position, avoiding any awkward or uncomfortable positioning.

The cab lining consists of fiberglass reinforced with a polyester resin (FRP), coated with a layer of gel-coat and painted. This material is extremely wear and abrasion resistant.

The cab is designed with specific soundproofing, with special attention to the roof, floor, cabinets, and HVAC ducting, in order to achieve an optimum sound level and provide a comfortable working environment for the operator. The main cab components are as follows:

- Operator’s console
- Operator’s seat
- Side cabinets to install project-specific equipment
- Windshield and side windows
- Cab door
- Lighting

The operator’s cab is considered an all-purpose work area therefore special emphasis is placed on the following:

- Ergonomics and comfort for the operator
- Visibility through the cab windshield with a minimization of blind spots
- Optimized passenger interfaces

- Optimized railway operation interfaces
- Rapid evacuation of the operator in case of emergency
- Aesthetics and customization of the cab

5.A.2. ERGONOMICS AND COMFORT

The design process for the operator's workstation has taken into account all possible criteria with regard to ergonomic engineering, with the aim of providing the highest levels of ergonomics, comfort, and safety.

The cab has been designed to achieve the best possible visual angles with a great aesthetic appearance. The internal layout of the cab is done to accommodate from the 5% female to the 95% male range of users. A visibility and ergonomic analysis has been performed and the design of the cab interface is continuously improved using operator feedback from streetcars in operation and general knowledge from our experts.

Vital elements of the evaluation of the design phase include:

- Operator console space: Minimum and maximum dimensions required by the operator
- Position and comfort of the operator's seat
- Accessibility of all controls on the operator's console
- Safety and ergonomics for the operator
- Visibility through the windshield, to rearview monitors and signs: Minimization of blind spots.
- Rapid access and egress for the operator.

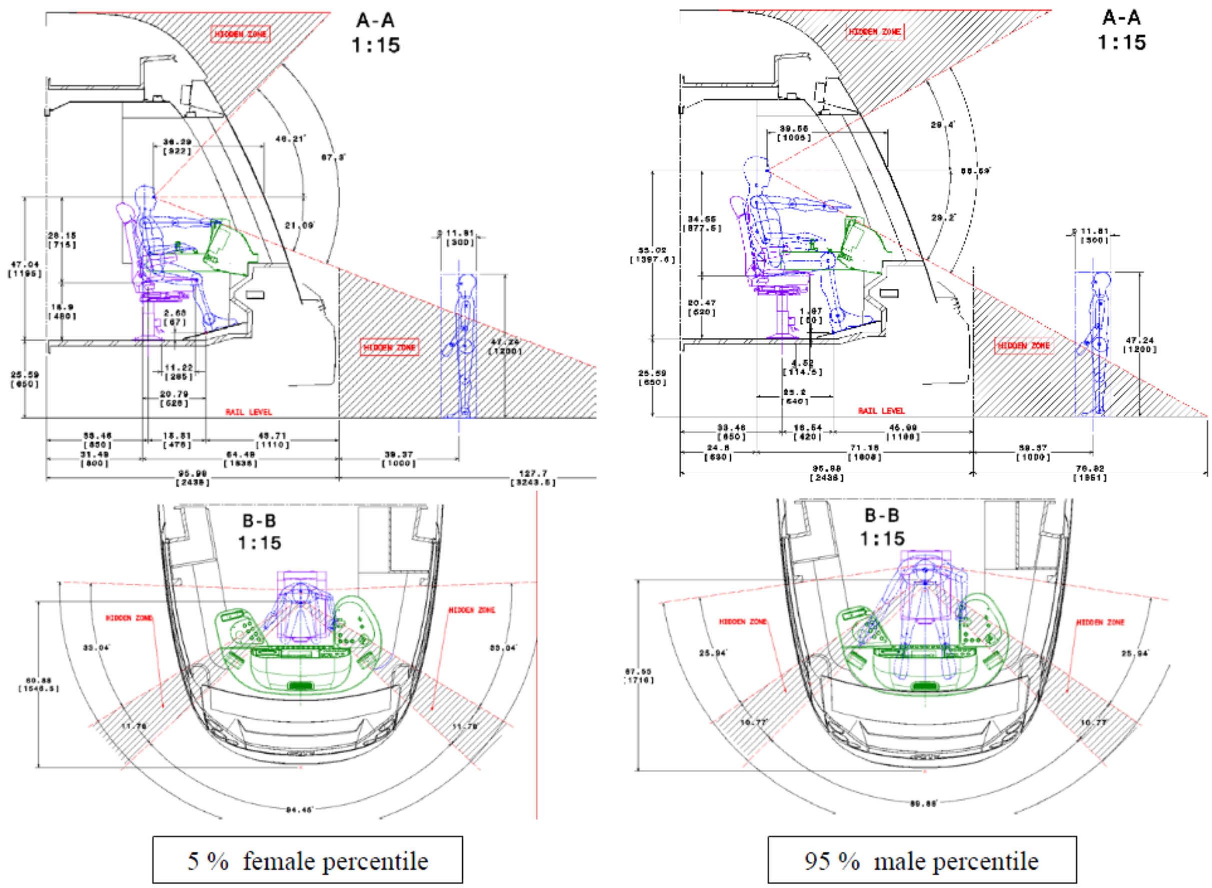


Figure 1. Visibility Analysis

5.A.3. CAB CONTROLS

Every cab has a control panel to operate the train. The equipment, indicators, controls, and other items required to run the train are located here.

The operator controls are studied in a common framework to prevent multiple controls and to ensure the conciseness of the messages sent. To this end, the equipment in the operator's work area is arranged as follows:

- All the equipment, indicators and controls required to operate the vehicle are located in the primary area.
- The equipment, indicators and controls used sporadically for driving are located in the secondary area, which the operator must be able to operate, handle, and consult while seated.
- Finally, the controls and indicators not required for normal operation/driving are located in a tertiary area. The operator can stand up to operate these.

The main items located on the console are as follows:

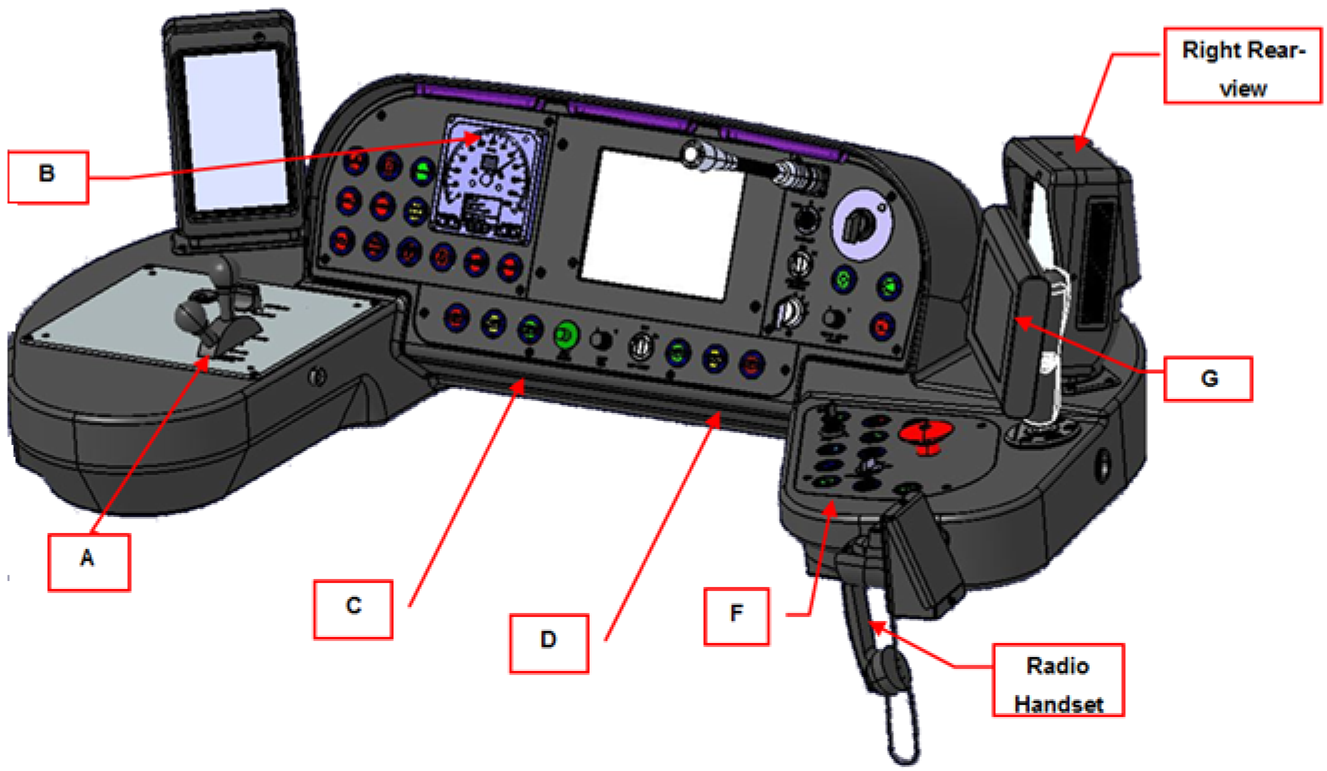


Figure 2. Operator Desk Layout

- A: Master Controller plate
- B: Speedometer, Indicators plate
- C: Left pushbuttons plate
- D: Right pushbuttons plate
- E: Control plate
- F: Emergency mushroom button plate
- G: Nextbus DCU (only in one of the cabins)

Other items, by location or size, are not mounted on plates:

- Left rear-view mirror monitor
- Right rear-view mirror monitor
- HMI – Monitoring and Diagnosis System
- Radio-handset

The desk console consists of fiberglass-reinforced polyester with a gel-coat layer and a matte texturized paint application, to prevent glare while being both wear and abrasion resistant and preventing color

fading as a result of use. It is easily cleaned as hard to reach corners and areas where dirt can build up have been avoided.

The console is designed in a modular fashion. It is a single, lightweight reduced-dimension item supported on a shelf included on the cab polyester cell. It can be easily removed from its base by means of screws and connectors, in order to revise connections and equipment, and replaced with another in the event of an accident.

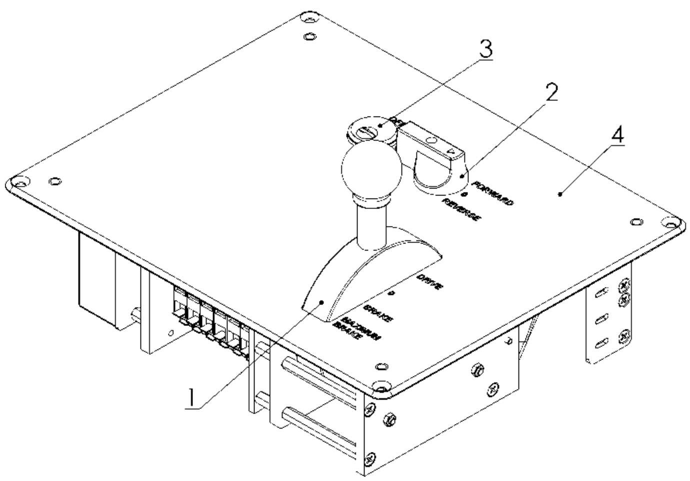
5.A.3.1. MASTER CONTROLLER

The master controller is used as control unit in the streetcar. It will be installed in the driver's console for left hand operation and includes the main operating elements shown in Figure 3.

Using the traction brake controller, the driver is able to control the traction power as well as the brake effort of the vehicle. Furthermore, the driving direction can be selected by using the reverser switch. The key switch is used to activate the whole master controller as well as additional vehicle functions.

Between components 1-3, a mechanical interlocking system is installed which avoids faulty operation of these components.

The Master Controller handle incorporates a deadman feature.



1	Traction brake controller
2	Reverser switch
3	Key switch
4	Cover plate

Figure 3. *Master Controller Board (I)*

Due to its special location and because of the handling of the master controller while driving, this board only contains pushbuttons with a sporadic actuation. Most of them only need to be activated when the streetcar is stopped. In Figure 4 below, the master controller is shown in coasting and maximum brake positions.

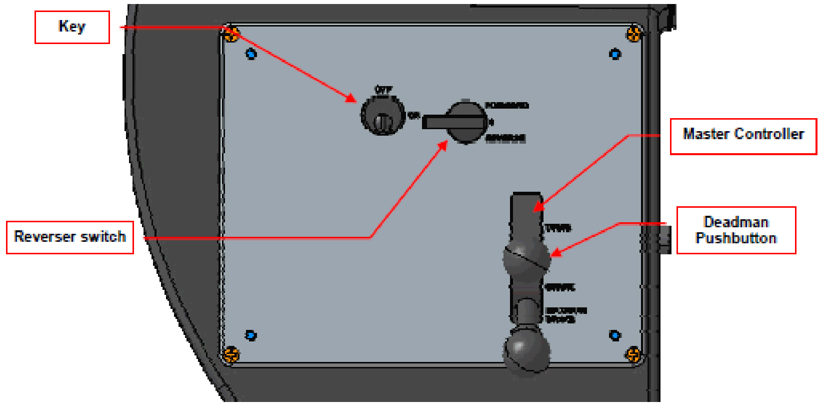


Figure 4. Master Controller Board (II)

Description	Function	Icon	Type
Key switch	• OFF Streetcar OFF: It's possible to extract the key • ON Cab enabling: It connects the streetcar and enables the cab for driving. The key is not removable in this position.	Text: • ON • OFF	Key
Reverser switch	It is used to select the driving mode.	Text: • Forward • 0 • Reverse	3 position rotary switch
Master controller	• Drive • Coasting • Brake • Maximum Brake (Emergency 3)	Text: • Drive • Brake • Maximum Brake	Angular handle
Master controller deadman device	Deadman actuator	N/A	Handle pushbutton

5.A.4. CAB ARRANGEMENT

5.A.4.1. CAB ACCESS

Access to the cab is provided through a door that opens towards the passenger compartment. The cab door is a fully laminated glass door, allowing the operator to see into the passenger compartment.

There is one single-leaf door in the area adjacent to the cab with access to the outside. As a result, although there is no direct access to the cab from outside, the passenger compartment door adjacent to the cab provides the operator with immediate access from a platform or the track.

The single leaf door adjacent to each cab is provided with interior and exterior crew switches. The crew switches electrically open and close the door. The door operation is available even though the vehicle is powered off.

5.A.4.2. OPERATOR'S SEAT

The operator's seat design is the result of an ergonomics study which takes into consideration various aspects such as the location of the console, sizes, etc.

The operator's seat is adjustable fore/aft and vertically. The backrest has a recline feature and it is equipped with a mechanically adjustable lumbar support. The seat has flip-up armrests and swivels at least 30º in either direction from the forward facing position. Upon returning to the forward facing position, the seat automatically locks into place, preventing further rotation.

All seat adjustment controls are operable from a seated position.

The seat is anchored to the floor by means of four screws to provide for swift and simple removal.

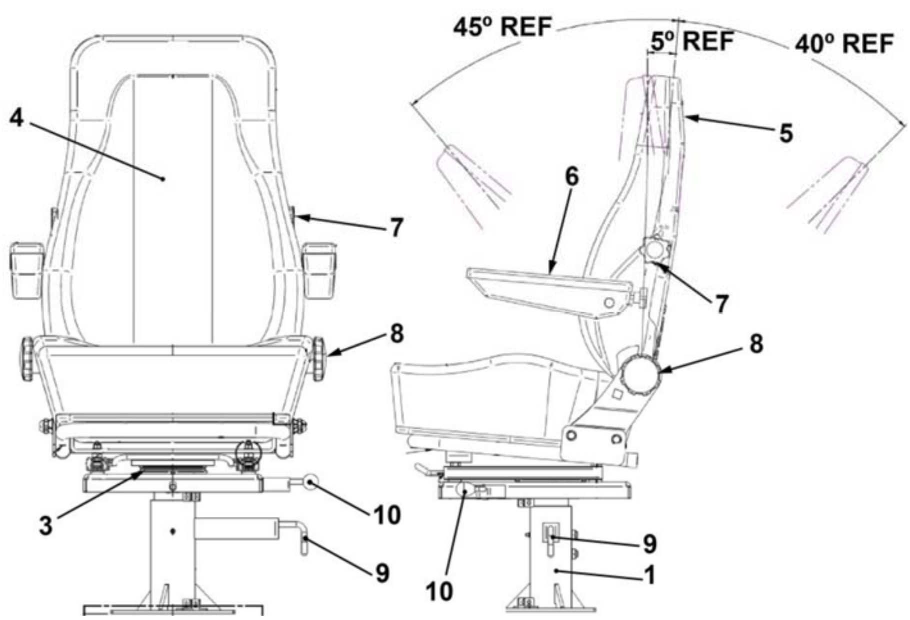


Figure 5. *Operator's seat*

No.	Description
1	Fixed base.
2	Seat frame.
3	Fore/aft adjustment handle: Bar that can be lifted to move the seat forward or back. Pull upward on handle to release lock and slide seat to desired position.
4	Adjustable backrest.
5	Adjustable headrest.
6	Flip-up armrest.
7	Backrest lumbar adjustment knob: Knob that can be rotated to adjust the level of the lumbar support of the backrest.

No.	Description
	Forward rotation increases the level of lumbar support; backward rotation decreases the level of lumbar support.
8	Back recline adjustment knob: Knob that can be rotated to adjust the angle of recline of the seat back. Rotate knob forward to mode seat back forward and rotate it rearward to recline seat back.
9	Height adjustment lever: Lever used to adjust the seat height.
10	Rotation knob.

5.A.4.3. SUNSCREENS

One electrically operated sunscreen is provided for the windshield. The sunscreen protects the operator from glare. The lower part of the sunscreen includes an entirely opaque 300 mm wide strip, to prevent light from entering this area. Manually operated sunscreens are also provided for both side windows.

Figure 6. Sunscreens

5.A.5. MISCELLANEOUS CAB EQUIPMENT

5.A.5.1. CAB SIDE WINDOWS AND WINDSCREEN

The cab has two side windows with the greatest dimensions possible. This design produces a large viewing angle for the operator. The corner posts have been reduced to a bare minimum, to minimize blind spots that may occur.

The formation of frost and the steaming up of windows is prevented by means of heating resistors included in the windshield and side window glass.

The cab side windows are horizontally sliding windows which can be opened with a latch only operable from inside the cab.

5.A.5.2. WINDSHIELD WIPERS AND WASHER

WINDSHIELD WIPER

Electric windshield wipers are provided. They have a double arm mechanism mounted in the center of the windshield that provides a sweeping motion from the left to right, cleaning the maximum area that this type of mechanism permits. In standby position, the windshield wipers do not obstruct operator visibility. The windshield wiper motor and its components are accessible from the front body-end.

This type of windshield wiper is service proven on other CAF vehicles, when running through car washers as well as during daily use.

The windshield wipers are activated via a switch on the operator console. This control can be accessed using the right hand with the streetcar in motion.

WINDSHIELD WASHER

The windshield washer reservoir is located behind a front shroud on the front body-end. This tank is accessible for filling from the outside, via a cap near the windshield wiper arm.

Liquid is sprayed via a tube and nozzle built into the windshield wiper arm, and a small pump, included as part of the water reservoir.

The reservoir has a low fluid sensor that annunciates on the Train Operator Display (TOD).

5.A.5.3. AIR COMFORT SYSTEM

The vehicle cab is provided with HVAC by the same units that supply HVAC to the passenger compartment. The ducting carries the conditioned air from the units to each operator's cab. One electrical damper is provided to adjust the conditioned air flow from the passenger area to the operator's cab.

Two floor heaters provide additional heat in the operator's cab.

In normal mode, cab heaters are controlled by the operator by means of the TOD screen. The operator can control the heat level (OFF, low, medium, high) and the cab heater fan speed (low speed / high speed). The Monitoring and Diagnosis System controls the heaters to get the desired heating level and fan speed.

When a cab is inactive, and the vehicle is powered, the cab heaters are controlled by a thermostat. If the temperature is below the thermostat setting, 25% of the heating capacity is switched on.

5.A.5.4. WARNING DEVICES

The vehicle is equipped with a horn with two volume settings, low and high. It is activated by a momentary switch in the operator's cab. The high horn volume setting has an audible output of at least 95dB at 100 ft. (30 m) in front of the vehicle. The low volume setting will be adjustable by the City.

The streetcar is also equipped with a traditional sounding trolley bell for pedestrian warnings. The bell has a minimum sound pressure level of 75 dB, measured at a distance of 75 ft. (23 m) in front of the vehicle. Activation is by a momentary switch in the operator's cab.

5.A.5.5. DRIVER VIGILANCE

The operator vigilance functionality is carried out by the Event Recorder.

The event recorder monitors the operator's presence by monitoring the activation of the operator vigilance signal (Master Controller Handle pressed).

If the operator vigilance signal is lost (Master Controller Handle released), a light and warning sound are activated in the cab. A full service brake is applied if driver vigilance signal is still missing after a timeout.

The driver vigilance is reset and the full service brake is released, by moving the master controller to Full Service Brake or Maximum Brake position.

5.A.5.6. CAB PARTITION

The vehicle cab partition is made of an aluminum plate and laminated glass (same type and tint as the cab door), which are securely fastened to the car roof structure, floor, and carbody side structure.

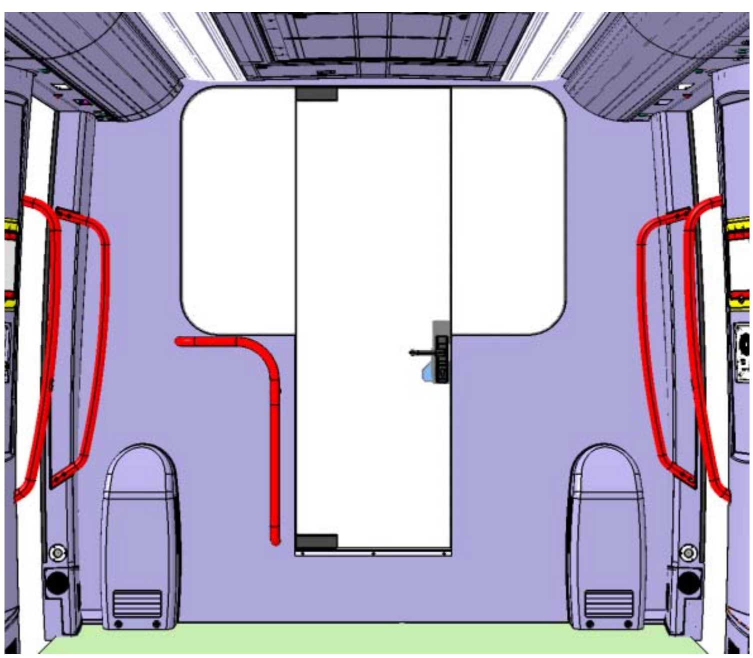


Figure 7. *Cab door and partition*

5.A.5.7. OTHER CAB EQUIPMENT

The following items will be provided to improve operator comfort:

- Spaces where the operator may store personal items, as well as a coat hook
- Supports and grab handles are included in the plans, helping the operator to enter, exit, and move within the cab.
- Waste receptacle
- Two (2) duplex convenience outlets, one in each cab
- A flip-down cup holder
- Fire extinguisher

5.B. OPERATOR CAB AREA PLAN AND ELEVATION DRAWINGS

Please refer to drawings Q.00.238.86.001 and Q.00.238.87.001 in Sub-part A General Description.

5.C. DESCRIPTION OF THE PROPOSED MASTER CONTROLLER GROUP

Please refer to section 5.A.3.1 MASTER CONTROLLER in this document.

5.D. ARRANGEMENT OF THE OPERATOR’S CONTROL CONSOLE

Please refer to section 5.A.3 CAB CONTROLS in this document.

TABLE OF CONTENTS

Sub-Part A – VEHICLE DESCRIPTION

Sub-Part A – VEHICLE DESCRIPTION

SECTION 6 PASSENGER DOORS AND BRIDGEPLATES

6.A. SCOPE

This section includes the technical description of the following elements:

- Passenger's Doors
- Bridge plates

6.A.1. GENERAL DESCRIPTION PASSENGER'S DOORS

The IFE Reverse Locking System (RLS) is a door design that is service proven in projects around the world. The figure 1 below shows the door arrangement on CAF's offered Streetcar.

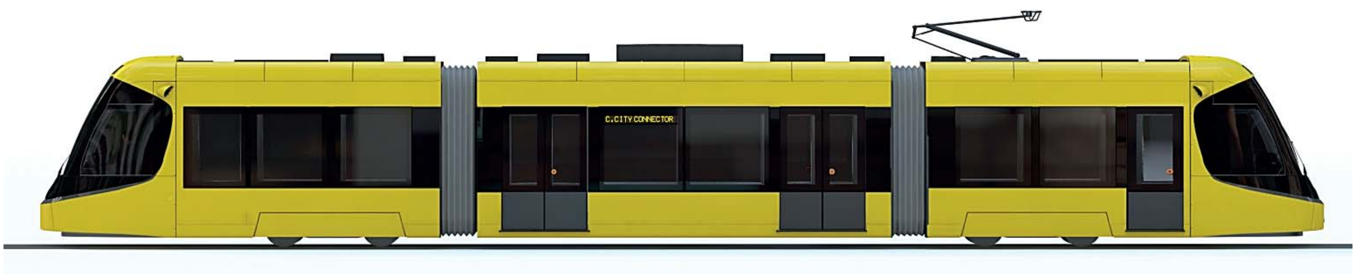


***Figure 1.** Overview of the standard door distribution*

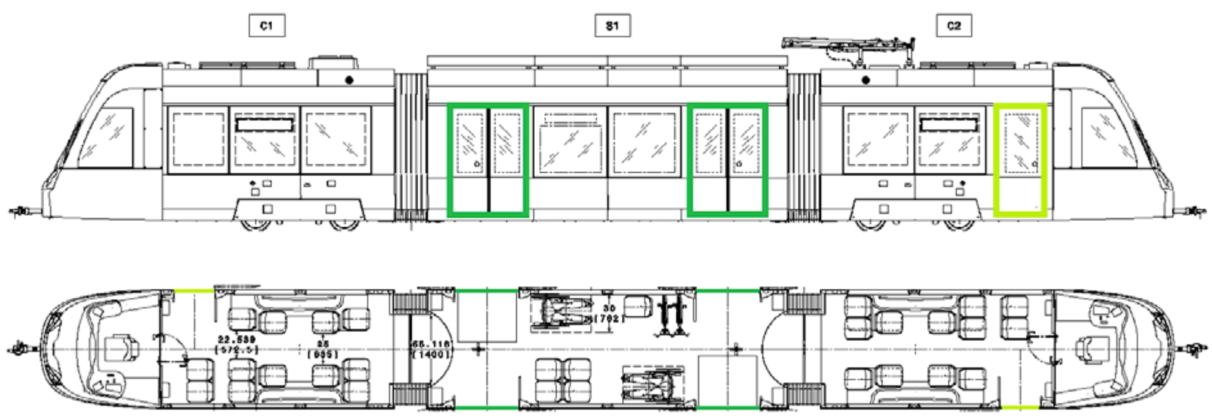


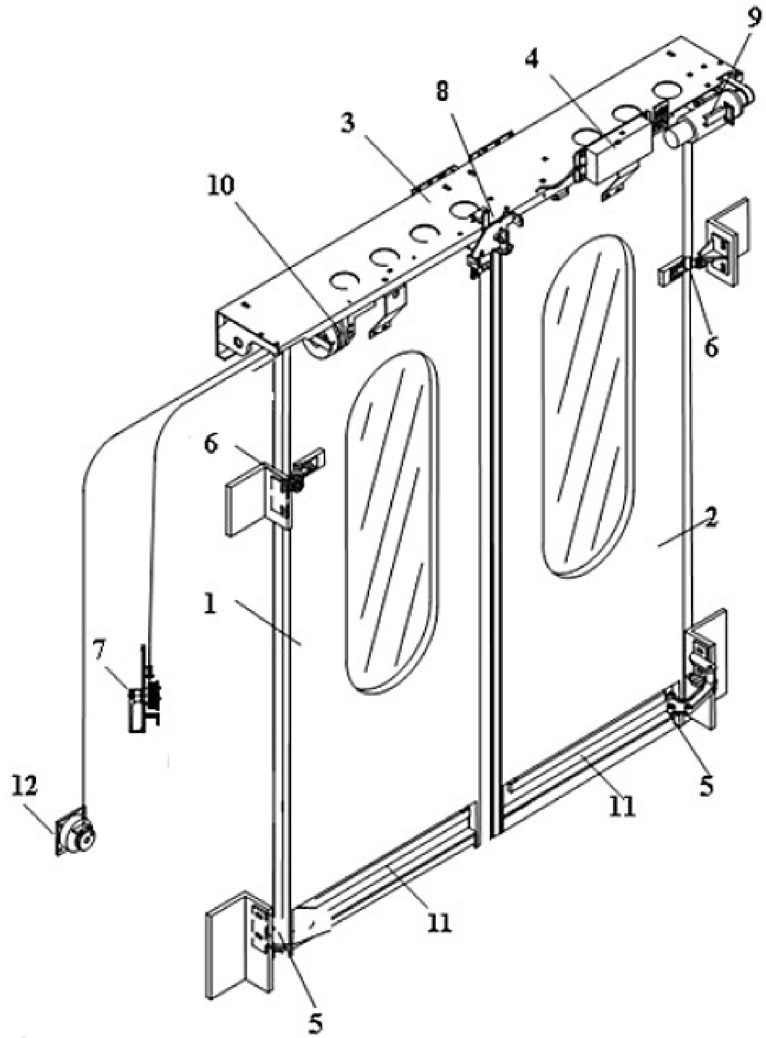
***Figure 2.** Overview of the customized door distribution*

Figure 2 represents the door distribution designated for vehicles for City of Seattle. Each vehicle has three (3) doors per side. Two (2) of them are of bi-parting sliding plug door, and one (1) is a single leaf sliding plug door.

The double-leaf doors are mounted in the middle car (S1), allowing fast and safe passenger entry and exit at the tracks. They also allow a safe and barrier free access for PMR in wheel chairs by a flat integrated ramp at one (1) double leaf door on each side of the vehicle.

The single-leaf door is mounted directly behind the driver's cab in car (C1 and C2). This door is used by the driver and the passengers for boarding and egress.

Each door consists of the following:



1. Left door leaf
2. Right door leaf
3. Operator (Drive Unit)
4. Control Unit
5. Roller swing arm
6. Support roller
7. Interior Emergency Manual Release
8. Cut-Out Mechanism
9. Door motor
10. Locking Unit
11. Guide rail
12. Exterior Emergency Manual Release

Figure 3. *Overview of Typical door system*

6.A.1.1. DOOR LEAVES

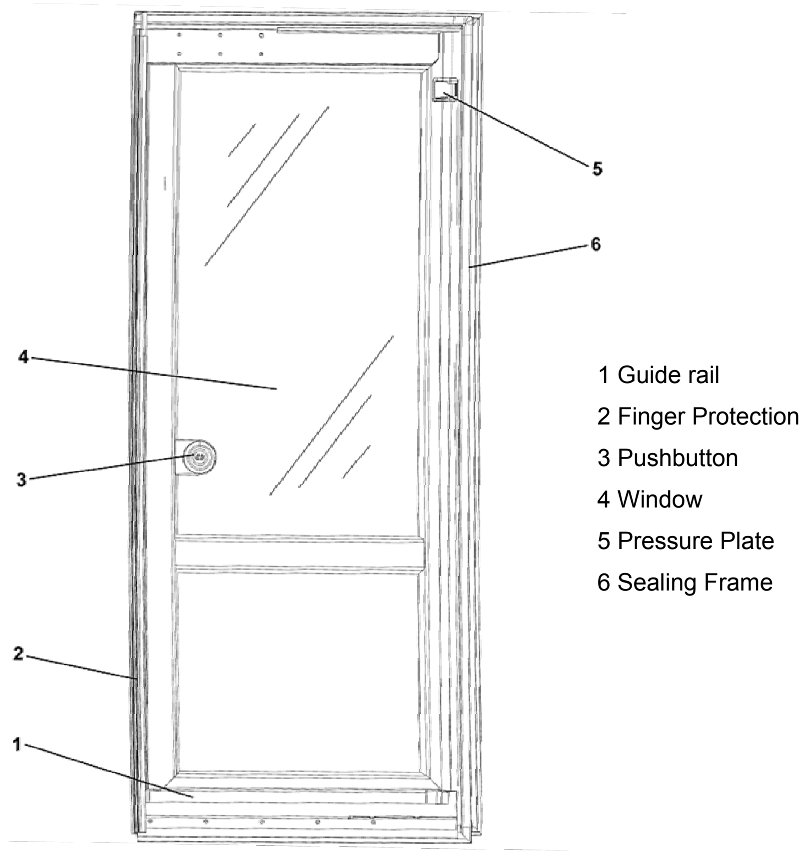


Figure 4. *Single leaf drawing*

The door leaf is a frame construction consisting of lightweight aluminum profiles with bonded panels on the outside. The rigid frame is powder coated to match the car's interior design and has channels for the surrounding seals and a surface for panels to be glued on the outside.

A painted aluminum panel matching the exterior of the car is glued onto the bottom portion of the door leaf. A kink of dihedral angle 6º is in each door leaf, and the seals of the door are designed to match the portal radii.

Each door leaf is equipped with surrounding rubber seals to protect the entrance against environmental influences, such as heavy rain, snow and ice, and a leading edge rubber that overlaps in the closed position. A pressure sensing strip is included in both leading edge rubbers to detect small obstructions.

A window is glued onto the upper portion of each door frame; the glass is a laminated safety glass of the same material and color as the side windows, and fulfills requirements of 49 CFR 238 FRA Type II.

The right and left hand single door leaves are equipped with a double sided Passenger Pushbutton. The right hand panel of the double door is equipped with the same double sided Passenger Pushbutton.

6.A.1.1.1 DRIVE UNIT

The pre-assembled drive unit is connected to the car structure via a base console. All the drive and locking components for one (1) entrance are mounted on the base console. The drive unit consists of following components:

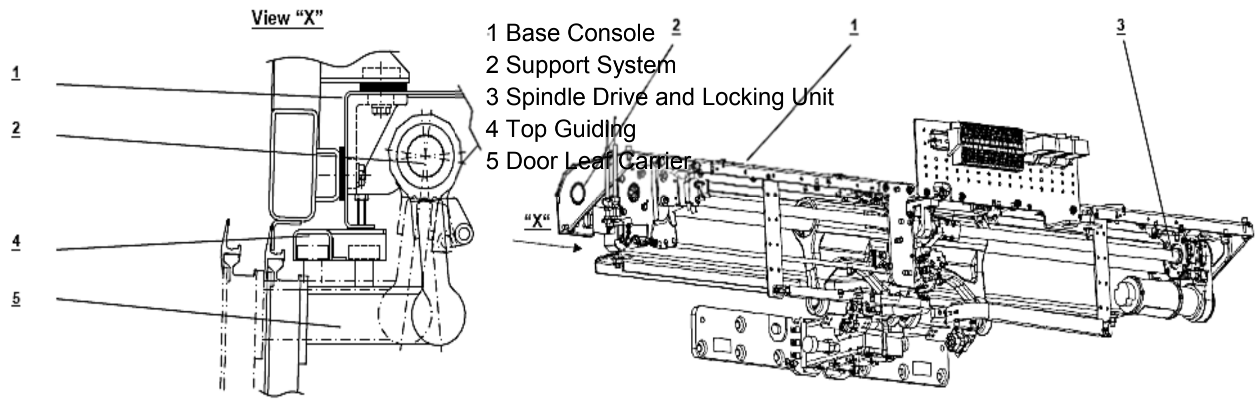


Figure 5. *Overview of Driver unit*

6.A.1.2. DOOR CONTROL UNIT

Each door is equipped with a door control unit (DCU) type MDC-24-ETH. The MDC controller is a platform/modular style controller, comprised of circuit boards specifically developed for this type of application, and is in use on various projects worldwide. The software programmable controller can handle both signal and power circuits. The DCU is developed according EN50155, EN50121-3-2 and IEC 60571. The DCU consists of a programmable logic with the necessary inputs and outputs, and a motor power circuit (inclusive safety relay) to control the door drive motor. Each DCU includes a CAN BUS Interface, a service button and an Ethernet service interface. Interface connector is a 9-pol. Sub-D connector with UNC4-40 bolt screw for can and M12 for Ethernet. The CAN BUS interface allows all DCUs to communicate with each other and the TCMS.

6.A.1.2.2 SOFTWARE

The DCU Software is based on a 3-layer model with proven software modules. The software is in "C" language, written in object-oriented styled subroutines. This allows the use of service proven modules to be combined as required for the different configuration door systems. The code is generally very compact, leaving memory available for future use. The program is stored in a flash EPROM. The software can be uploaded directly from a laptop, eliminating the need for burning and changing out

chips. Software development and documentation is according ISO9000-3 or EN50128. IFE will provide documentation for SIL 2, according to EN20128.

6.A.1.3. BOTTOM DOOR LEAF GUIDING (ROLLER SWING ARMS)

One (1) roller swing arm per door leaf is mounted on the bottom sides of the portal. Three (3) rollers on the swing arm engage the guide rail, which is fastened to the door leaf. The special shape of this (lower) guide rail, together with the roller swing arm, causes the door leaf to move synchronous to the movement of the support system. The roller lever also keeps the closed door in its position as well as ensures parallelism to the car body when in the open position.

For stabilizing the door leaves in the closed position, support rollers (Pos. 6 in figure 3) are mounted on the sides of the portal near the drive unit. They keep the upper trailing edges of the door leaves in position and help to press the lower area of the leading edges together.

6.A.1.4. EXTERIOR MANUAL EMERGENCY RELEASE

The exterior manual emergency release device can be operated regardless of whether power is applied to the door system. The emergency access device is a rotary device which can be operated with the turn of the handle. The actuation of the device will first actuate an electrical switch annunciating the status and breaking the door closed safety loop, then mechanically disconnect the brake unit, allowing free movement of the door panels if the vehicle is at stand still. When the vehicle is in motion, the break in the door closed safety loop will cause full service brake to be applied until the vehicle stops. Additionally while the vehicle is in motion, the motor of the door drive unit will be used to hold the door leaf in the closed position. When actuated in the fully closed position the door panels will open approximately 25 mm (1 inch) when released.

Figure 6. *Exterior Manual Release Device*

6.A.1.5. INTERIOR MANUAL EMERGENCY RELEASE

The interior manual emergency release is operated by a pull handle which allows the opening of the door by hand in an emergency situation. With the exception of the style of operation the function is identical to that of the exterior emergency release. The device is reset by using a crew key. The limit switch will detect status of the switch position and provide indication that the lever is activated.

Figure 7. *Interior Manual Emergency Release*

6.A.1.6. DOOR CUT-OUT MECHANISM

A mechanical cut-out device will be provided for each door entrance located on the operator in the cover area. The device will be mounted at the center of each double door entrances and on the closed end of the single door entrances on the interior of the car.

When actuated to the cut-out position the device locks the doors mechanically in the closed position and electrically bypasses the “door closed loop”. The device latching can only take place when the doors are brought to or in the fully closed position. A linkage bar to the emergency release will allow an emergency release device to override the door cut-out device and open the door.

6.A.1.7. INTERIOR/EXTERIOR CREW DOOR SWITCH

Crew Door Switches will be provided at two (2) entrances that will allow door opening and closing at the local entrance via key, from the interior or exterior of the car. The switch will be a three (3) position switch with spring back to the neutral position.

6.A.2. DOOR LOCKS

A tooth brake locks the door. Unlocking of the door happens by energizing the brake via the door control unit or by engaging the brake with the emergency devices. This action will separate the toothed clutch and release the spindle to turn. The force of the brake is transmitted through the door system as follows:

- Brake locking the spindle via free wheel clutch(locked in opening direction)
- Spindle
- Spindle nut
- Linkage to the trolley
- Door leaf carrier fastened to the door leaf

When the brake is not released, the door is locked. If the door is not in a closed position, the free wheel allows further closing by means of the motor or, in case of a failure, by hand. Therefore, the locking is not sensitive to a special door-position.

6.A.3. PERFORMANCE

Product Specification	
Door-System	single leaf door: RL2-e1 double leaf door: RL2-e2
Low Voltage Power Supply	24 VDC ± 30%
Free throughway opening width	single leaf door: 813mm double leaf door: 1300mm
Opening time door/ Closing time door	single leaf door: 3.5sec. ±0.5sec. (adjustable parameter) double leaf door: 3.0sec ±0.2sec. (adjustable parameter)
Average power consumption	< 180W (door opening sequence) < 120W (door closing sequence)
Maximum power consumption door (locking, unlocking, reversing)	< 500W (< 500 msec.)
Test bar for obstacle detection without sensitive edge active	Test bar: 30x60mm, edge-radius: 5mm Inspection method: acc. EN14752
Test bar for obstacle detection with sensitive edge active	Test bar: 10x75mm, edge-radius: 5mm AND round 20mm
Squeezing forces at door closing sequence	< 130Neffective first closing sequence < 200Neffective further closing sequences < 300NPeak
Obstacle removal force	< 150N
Warning Buzzer Tone	1900 Hz

Table 1. *Door Performance*

6.A.4. DOOR OPERATION AND CONTROL

The door control electronics and the control software prevent the unlocking and opening of a door/step during the train is moving. Any failure will be automatically detected through diagnostic functions.

During normal operation, doors are opened by the passenger by use of a double-sided passenger button. During heavy use periods, however, operators have the ability to open and close doors to speed up ingress and egress. Additionally, the doors can be manually “cut out” by the operator or maintenance staff.

6.A.4.1. DOOR OPENING

The opening sequence of the door after a valid opening command is as follow:

1. Activation of warning buzzer.
2. Activation of output, which unlocks the tooth brake.
3. The door drive motor will be activated in the opening direction.
4. The door leaves, the closed position and the limit switch “door closed” will be deactivated.

5. The door drive motor will be deactivated as soon as the door has reached the open end position (monitored by the door position sensor) and output (unlocking of the tooth brake) will be deactivated.

Opening by passengers (open pushbutton)

Each entrance is equipped with open pushbuttons (inside and outside), that allow door opening by passengers. Therefore the door has to be enabled for door opening (i.e. enable signal active).

As long as the DCU detects a valid enable signal, the green LEDs of the pushbuttons remain lit. If the pushbutton is operated at an enabled door, an open command from the open pushbutton will open the door. Door opening by passengers is only possible if the enable signal is active. If the door is released and the open pushbutton is pressed while the door is activated in the closing direction, then the door will be re-opened.

Opening by passengers (stop request)

If the stop request pushbutton was activated when the opening conditions are not available then:

- A signal to the VCU is sent, providing information to the driver.
- Buzzer is activated during time the pushbutton (hardware) is depressed.

Opening by Operations staff (“open door” hardwire/bus signal)

The signal “open door” is connected to the DCU by hardwired signal and by bus-signal. If the bus-system is not available, only then hardwired signal will be evaluated. The driver has the possibility of opening each single door in the vehicle directly by activating the “open door” signal. This is only possible if the enable signal is active.

Activation of warning buzzer is defined with an interval of 21Hz. The activation starts at the same time with the open movement. This open warning sequence has a higher priority than the enable warning sequence, which is caused by activating the enable signal. If the “open warning” is deactivated then the “enable warning” is carried out.

Opening by Operations staff (crew door switch):

If the crew switch is activated in the opening direction, then an external circuit will activate the supply voltage for the DCU, and activate the enable signal at the input and activate the speed signal for approximately 60 seconds.

Operating the crew switch in opening direction carries out the following function under following starting conditions:

- **Train is shut down and door is closed:**

  The crew switch must be activated at least for 5 seconds to power up the DCU, until the door starts to open. The door will then work according to the proximate signals.

- **Train is shut down and door is not closed:**

  Same function as “Train is shut down and door is closed”.

- **Train is shut down and door is emergency operated:**

The crew switch must be activated at least for 5 seconds to power up the DCU. The door will stay in its current position and the opening command from the crew switch will be stored. After a reset of the emergency device during active power supply, the door will be opened. The DCU cannot monitor the current door position after power up, therefore the door will be opened with an initialization routine until the door has reached the closed position (reference position for position sensor).

- **Train is powered up (door is closed or door is not closed):**

  The activation of the crew switch will have no influence on the operation of the door system.

The door can be manually opened in an emergency by a passenger or operator by pulling the interior/exterior manual release. The manual emergency release device can be operated regardless of whether power is applied to the door system. This action activates a maximum service brake stop if the vehicle is in motion.

Emergency device inside

To open the door manually in case of emergency, each door in the vehicle is equipped with an internal emergency device, which is built as a flap handle with a locking point in the actuated position. The door is unlocked by means of a Bowden cable and can be opened manually. Emergency opening on a door which is isolated is possible. If the handle is pulled the limit switches are actuated, the tooth brake is unlocked, and the emergency handle will stay in the activated position. The interior and exterior door status indicators are illuminated.

Operating the door emergency device will actuate the limit switches at the door drive system

- **If zero speed signal is active**
  - A signal is given to the DCU which switches off the door functions.
  - Operating the emergency handle, the Bowden cable will unlatch the tooth brake and the door leaves the closed position so that the door can be opened manually.
  - The bus signals “door emergency device activated” is sent to the VCU.
- **If zero speed signal is not active or becomes inactive**
  - A signal is given to the DCU which activates the door drive motor in closing direction until the v<limit; signal becomes active for a maximum for 90 sec. (thermic reasons).
  - The bus signal “door emergency device activated” is sent to the VCU.

Additionally, one N.C. contact of the limit switch emergency device is connected in parallel with an external contact of the train zero speed signal, used for activation of the contactor. This means the contactor is steady activated if the train is moving or the door is not emergency operated.

If the door is emergency operated at a vehicle speed lower than the limit, then the contactor will be deactivated, which will interrupt the motor lines, i.e. the DCU cannot activate the door drive motor.

The internal emergency device is equipped with a crew key, which is used to reset the emergency device.

Emergency device outside

To open the door manually in case of emergency, the end doors at the train are equipped with an external emergency device, which is built as a rotary device which can be operated with the turn of the handle. The door is unlocked by means of a Bowden cable and can be opened manually.

Emergency opening on a door which is isolated is possible.

Operating the door emergency device will cause the same sequence of signaling as described for the internal emergency device. The external emergency device can be reset by turning the crew key back to the normal position. After the emergency device is reset (limit switch signal gets inactive), the door will work accordingly.

6.A.4.2. DOOR CLOSING

The closing sequence of the door after a valid closing command will be as follows:

- The door drive motor will be activated in closing direction
- As soon as the door has reached the closed position, the limit switches “door closed” will be activated and the door drive motor will be deactivated
- The unlocking test of the door will be performed, after each door closing sequence.

If the locking test fails then the door will remain in its position and the DCU generates a diagnostic code. The door closed loop will not be closed.

Closing by train staff (central closing)

Please refer to next paragraph.

Closing by train staff (at deactivated enable signal)

When the enable signal is deactivated, then the green LEDs in the push button are deactivated and an open door will close after a pre-warning time of set time. The warning elements will be deactivated when the door is closed.

If no valid forced closing bus signal is detected by the DCU, then the warning buzzer and the warning lamp are activated with an interval of f31-Hz.

If the DCU detects a valid forced closing bus signal then the warning elements are activated - warning buzzer and the warning lamp are activated with an interval of f51-Hz.

If the enable signal is deactivated during the door opening sequence, then the door will stop immediately and will close. Reopening by the push button is no longer possible. The obstruction detection system is active.

If the enable signal gets active again during the closing sequence, then the door can be re-opened by one of the following conditions:

- Activation of the open push button
- Open door signal is activated

- Obstruction detection system gets active

Closing by train staff (crew door switch)

Operating the crew door switch in closing direction carries out the following function under the following starting conditions:

- Train is shut down and door is closed

  The door can be powered up with the crew switch (therefore crew switch must be activated for at least 5sec), but the door will stay closed. The activation of the crew switch in closing direction will have no further influence on the operation of the door system.

- Train is shut down and door is not closed:

  The crew switch must be activated at least for 5 seconds to power up the DCU. As soon as the DCU has received the closing command from the crew switch, the door will close after a pre-warning time. During the warning time and the closing sequence, the warning elements are activated are activated with an interval of f31-Hz:

  – warning buzzer

  – warning lamp

  The warning elements will be deactivated when the door is closed.

  Closing at deactivated speed signal will be deactivated during this closing sequence, until the door has reached the closed position. The open push button will be deactivated during this sequence. The obstruction detection system is active.

- Train is shut down and door is emergency operated:

  The crew switch must be activated at least for 5 seconds to power up the DCU. The door will stay in its current position and the closing command from the crew switch will be stored. After a reset of the emergency device during active power supply, the door will be closed. The DCU cannot monitor the current door position after power up; therefore the door will be closed with an initialization routine until the door has reached the closed position.

- Train is powered up (door is closed or door is not closed):

  The activation of the crew switch will have no influence on the operation of the door system.

Closing at deactivated speed signal

If the train control system generates a signal that indicates that the train exceeds a zero- speed then an open or opening door will be closed immediately. This operation will be done with highest priority and means that even if the enable signal is still active the door will close. The warning elements (buzzer and warning lamp) are continuously actuated at the same time as the door starts with its closing sequence. The warning elements will be deactivated when the door is closed. The open push button will be deactivated during this sequence. The obstruction detection system is active.

Automatic closing

All doors that have been enabled and opened by means of the push button or the signal “open door” will start their closing sequence automatically after a defined time. This period starts when the door reaches the open end position and starts again if the open push button is activated, before the period is elapsed. After the period is elapsed, the pre-warning time starts. When the pre-warning time has elapsed, the door starts to close. During the pre-warning time and the closing sequence, the following warning elements are activated with an interval of f31-Hz:

- warning buzzer
- warning lamp

The warning elements will be deactivated when the door is closed. If a passenger is detected during the warning period, then the warning elements are switched off and the period starts again.

If the door is enabled, it is possible for passengers to reopen a closing door by:

- activating the push button
- activation of the obstruction detection system

If a diagnostic code occurs during door is open then:

- door will not close automatically
- red LED´s from push button are flashing 1Hz

6.A.4.3. LOSS OF SUPPLY POWER

A loss of supply power will cause the following situations:

- an open door will stay in its current position.
- a closed door will stay in its closed position.

6.A.4.4. SAFETY RELAY

The safety relay (K1) is located on the DCU. The relay has two mechanically guided contacts which are simultaneously operated. The relays are only switched on by activating the trainline “door release”. For safety reasons, it is not possible to switch on a relay by energizing an output of the DCU. However the relay is energized, it is latched by a bypass circuit that is internally built into the DCU and a NO (normally open) contact of the respective relay. The relays are switched off by deactivating the respective DCU latch output when the trainline “door release” (central close command) is deactivated and when the door has reached the “Closed” position.

The contacts of the relay are used for following purposes:

1. One NO-contact (K1) is serially connected to the output of the brake. Therefore, the door can only be unlocked by a signal from the DCU when the relay (K1) is switched on (hardware interlock). This NO contact is also used for the latch circuit of relay K1 and gives the monitoring signal of relay K1 to the micro-controller.

2. One NC-contact (K1) is serially connected to the interlock loop for the door status relay circuit. The loop is closed if the door is closed and the relays are switched off, i.e. the interlock loop for the door status relay of the vehicle control remains interrupted until both safety relays are switched off.

6.A.5. DOOR OBSTRUCTION DETECTION

6.A.5.1. ON CLOSING SEQUENCE

During closing sequence, trapped obstacles are monitored by following systems:

a) Motor current monitoring

The curve of the normal motor current during closing sequence is stored and automatically adjusted on each closing sequence. If actual value of motor current exceeds the nominal value of the obstacle detection threshold, then an obstacle is detected. The maximum current is not constant over the length of the opening/closing cycle but depends on the door position and on the current consumption of earlier closing sequences (self-learning maximum current curve). The value of the last saved maximum current curve is saved even when the supply voltage of the door control unit is switched off.

b) Way/Time monitoring.

The door position sensor allows for monitoring of the door position in small increments. If positions are not reached within predetermined times, an obstacle is detected.

c) Sensitive edge

The door edge is equipped with a rubber profile and sensitive edge system. If the door meets an obstruction, the sensitive edge provides an active signal to the door control unit and an obstruction is detected.

If an obstruction is detected, the door will open completely or partially depending on the closing mode; this procedure continues until the door is closed or the door will remain in the position after an adjustable number of closing attempts.

6.A.5.2. ON OPENING SEQUENCE

During the opening sequence, obstruction detection is monitored.

If an obstacle is detected, the door movement is stopped for two seconds and afterwards, the door tries to continue the open cycle. After the third attempt, the door stops and the door control unit accepts this position as the maximum reachable open position.

6.A.6. DOOR CONTROL SIGNALS

The diagnostic signals may be shared via a local Ethernet link on DCU via a computer running the “DIAG” Service Software. The Door Control Unit provides an M12 Ethernet connector. The door and the door control unit are continuously checked for the following conditions:

a) DCU internal checks (hardware):
   - o EPROM (CRC checksum)
   - o RAM
   - o NOVRAM
   - o Runtime Watchdog
   - o Oscillator Watchdog

b) Plausibility checks:
   - o The movement of the door and the corresponding input signals coming from limit switches or push buttons, etc., are checked continuously against required and known operating conditions, time outs, or failure conditions.

c) Monitoring of the output current:
   - o All outputs are monitored for short circuits
   - o The motor output is monitored for broken wires

If a door is isolated, the logging of diagnostic data of the door is immediately switched off.

All already recorded diagnostic data is retained.

The diagnostic memory is subdivided into

- Foreground memory (current fail conditions)
- Background memory (temporary fail conditions).

The foreground memory contains current diagnostic data, i.e., diagnostic data which exists at the time of the inquiry.

The background memory contains temporary diagnostic data, i.e. diagnostic data previously observed by the DCU, but not active at the moment of data transmission from DCU to PC or changed into temporary diagnostic data by circumstances (i.e., by itself or an action of train personnel).

Current diagnostic data becomes temporary diagnostic data:

- Automatically, if a previous faulty state clears and the door works correctly again.
- If the reason for the diagnostic code is repaired by the train personnel (not by isolating the door, however).

A change from current diagnostic data to temporary diagnostic data is done in order to preserve this diagnostic information for the workshop.

With the use of a laptop computer and the diagnostic software, the diagnostic data can be read out, stored, and managed with the use of a database. The Door Control Unit provides a M12 interface connector. Software updates must be done with the separate Service Software “UPDATE”. Adjustments

of Software Parameters (door open stay time, opening and closing times) will be done with IFE Service Software "MonitMe."

6.A.7. GENERAL DESCRIPTION BRIDGE PLATES

The Bridge plate system main features are the following:

- Electrically deployed and retracted.
- Flushed-mounted and complete integration with the vehicle.
- Suitable for intensive use.
- Includes obstacle detection systems.
- Non-skid surfaces.

The RF2 Bridge plate system has been designed and developed in order to meet the latest version of the following standards:

- EN 14752
- TSI PRM
- **49 CFR 38.83**
- EN 45545
- EN 50121
- EN 50155
- IEC 61373

The figure below represents the main mechanical components of the bridge plate system.

1 Threshold / Front plate
2 Front edge polymer pieces
3 Obstacle detection system
4 Slide unit
5 Transmission
6 Mode selector
7 Top cover/Front cover
8 Bridge plate cassette

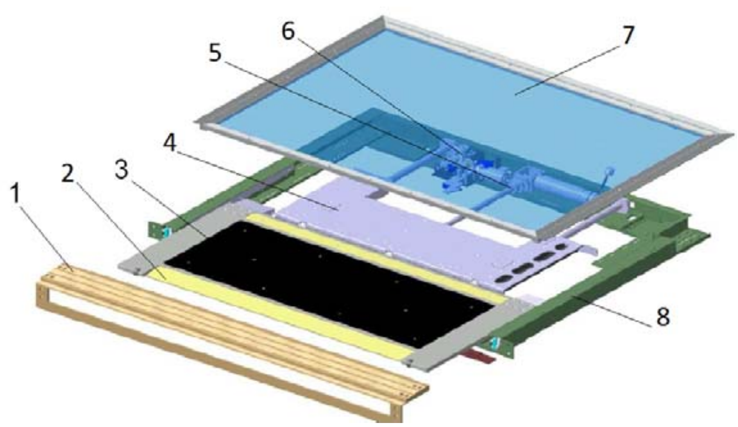


Figure 8. *Main components of bridge plate*

6.A.7.1. THRESHOLD

This is a structural component fixed to the vehicle and allows the integration of the Bridge Plate and the access door. This part is bolted to the vehicle structure and covers completely the clear width of the

access doors gate. As an structural part, it is able to resist the passenger's weight and any load up to 300 kg (661 lbf). The Bridge Plate threshold provides an interface between the Bridge Plate Front Cover and the vehicle, and also between the door leaves and the vehicle. This threshold is heated to avoid the formation of ice. The heating element can be controlled by the vehicle main control system. The lower part of the threshold has some machined slots to allocate the installation of the heating element.

6.A.7.2. FRAME

The frame is a structural system component, made of bended carbon steel plates with protective coating, fixed together with rivets. This frame is in charge of attaching the Bridge Plate to the vehicle and supporting all the internal parts and components of the Bridge Plate. This part includes the fixing points between the system and the vehicle, and at the front side it will be rigidly fixed to the threshold unit.

6.A.7.3. FRONT COVER

The hinged front cover holds sealing profiles which can be easily replaced. The front cover needs to be opened for manual deployment, to proceed with this function a lip shape is added to the extrusion profile of the front cover to allow hand grabbing.

6.A.7.4. MODE SELECTOR

Its function is to assure the blocking of the bridge plate when stowed, to allow the manual operation when necessary and to provide all the Bridge Plate condition (states) signals to the electronic control unit. In order to use the Bridge Plate, an unblocking system is activated by means of a simple effect linear electromagnet. A spring ensures the blocking position when the system is in idle state, and a micro switch informs about the Bridge Plate position (NC configured when stowed and blocked). The system is also responsible of the non-automatic operations. By means of a key-turn (outside, ¼ to the right or left turning) the system works accordingly.

6.A.7.5. TRANSMISSION

The power is generated by a continuous current (DC) motor that includes a brake and an encoder.

The ball screw of the spindle receives power motion by means of an angular gearbox (to allow movement of the Bridge Plate Unit). The ball screw is fixed to the slide unit allowing the extraction and the stowing of the Bridge Plate Unit. There is a secondary transmission system composed of two guides for two linear ball bearings (for each guide). The linear ball bearings provide the sliding motion and transmit the tensions from bridge plate's mobile parts to static parts.

6.A.7.6. SLIDE UNIT

The slide unit is fixed to the transmission and includes the hinges that allow the Bridge Plate Unit tilt movement. It is a structural part of the system which consists of a bended and riveted sheet metal made of carbon steel.

6.A.7.7. LIFTING MECHANISM

This mechanism is introduced as a feature of the Bridge Plate. It is designed to fully comply with ADA CFR 49 Part 38 Section 38.83. This mechanism uses the linear motion of the slide unit to rise the rear part of the platform. This mechanism is activated in the last portion of the slide unit's stroke. The mechanism executes the rear part of the platform rising in order to virtually erase the vertical GAP between the platform and the end point of the threshold.

6.A.7.8. BRIDGE PLATE UNIT

It is made of anodized aluminum in order to optimize the device's total weight. It is made from a single slab and machined to allow all bridge plate detection devices, obstacle detection and safety features to be attached. The bridge plate unit is attached to the lifting mechanism to achieve the movement and to cover the vertical gap. Its thickness is 15 mm (0.56 in); it contains visual warning strips and anti-slip surfaces for the user's protection.

6.A.7.9. WEAR STRIP

As the front edge of the bridge plate slides over the platform at the last section of the deployment stroke, some damage can occur to the platform. Therefore, the front edge of the bridge plate includes a “sacrifice” piece made of a technical polymer, which is easily replaceable.

6.A.7.10. OBSTACLE DETECTION SYSTEM

The bridge plate includes an overcurrent based obstacle detection system. Monitoring the current consumption and the speed of the DC motor, the control unit can detect the presence of an obstacle.

6.A.7.11. SENSITIVE MAT

The bridge plate includes a safety mat in the center zone of it. It is designed to increase people's safety, by stopping the bridge plate’s movement in case of contact between the mat and the user. The sensitive mat is not able to detect people under 20 kg (44 lb).

6.A.8. PERFORMANCE

Description	Value
Total weight	80 kg
Load capacity	> 300kg
Standard platform width	1300 mm (51.18 inch)
Standard stroke in step configuration	350 mm (14 inch)
Standard platform length in ramp configuration	600 mm (24 inch)
Mechanical limit in ramp configuration	30% / 18º
Extension speed	approx. 100 mm/sec.
Temperature range	-30ºC to + 70ºC
Cassette height	75 mm (3 inch)
Vertical gap covered (in mechanical limit)	210 mm (600 mm platform)

Table 2. *Main technical characteristics*

6.A.9. BRIDGE PLATE OPERATION AND CONTROL

6.A.9.1. AUTOMATIC MODE

6.A.9.1.3 DEPLOYMENT

The driver will be informed by a visual and acoustic signal in the driver's cab, when the inner or outer bridge plate request pushbutton was applied. The operation deployment will be executed under following conditions:

Deployment when "Bridge Plate enable" signal is activated

In this situation, the "Open command" is received when the "Bridge Plate enable" signal is activated. It means the enable signal from the door ECU is still active and received by the Bridge Plate ECU. In this case, the sequence to deploy the ramp is as follows:

- "Bridge plate enable" signal active.
- "Open command" signal active and "Bridge plate enable" still activated.

If this sequence is done, the deploy movement starts.

Deployment while it is retracting

If the "open command" is received while the Bridge Plate is retracting, this signal is ignored until the Bridge Plate is completely retracted. Then, a new "open command" has to be received to initiate a new deployment.

6.A.9.1.4 RETRACTION

The retraction movement starts when a "close command" is received. The "Bridge Plate enable" signal is not required to retract the Bridge Plate. It avoids keeping the ramp deployed in the event that this signal does not work (wiring incidence, door ECU error etc.). Once the order to retract has been received, the functioning sequence is:

- The Bridge Plate system carries out an obstacle detection diagnosis (like the sensitive mat). Any error in these systems is evaluated by the ECU to abort the automatic retraction process. An override signal must be received to completely retract the Bridge Plate.
- The power supply to the motor brake is cut off.
- Activation of the motor, starting the Bridge Plate retraction.
- When the "blocked and closed switch" signal is received, the motor power supply is cut off.

6.A.9.2. MANUAL MODE

The Bridge Plate can be manually deployed; this feature is provided for an emergency evacuation event only. The manual deployment is a degraded service of the Bridge Plate. When manual mode is engaged there is no energy supply to the motor and to its brake. When the Bridge Plate is deployed in

manual mode it does not lift thus a vertical gap exists between it and the threshold. When the Bridge Plate is deployed in manual mode it is not locked by the motor brake thus the Bridge Plate could wiggle. The manual operation is enabled by turning the operation mode selector 1/4 turn counterclockwise from automatic operation to manual operation. That turn allows unlocking the interior Bridge Plate system lock by means of a mechanical rod system. At that time the Bridge Plate can be manually retracted. Simultaneously, and by means of a switch, the power supply to the motor is cut off and an order to ignore any automatically operation signal is received by the ECU. Due to the reversibility of the system, and as long as the locks are disabled, the Bridge Plate can be manually retracted with a force no greater than 150 N (33.72 lbf).

6.A.9.3. OVERRIDE MODE

6.A.9.3.5 DEPLOYMENT

In the case of a sensitive mat failure (ECU does not receive the diagnosis signal or it always receives a true state of this signal), over-consumption of the motor or speed detection is detected before/during the deployment, the Bridge Plate movement will stop automatically. If a complete deployment is necessary, the open command signal must be kept activated until the Bridge Plate achieves the maximum deploying position. In this condition, the Bridge Plate moves ignoring the environment (users etc.). The override is active while the “open command” is activated. When this signal is deactivated, the movement continues but the override characteristic is disabled and the obstacle detection is reactivated.

6.A.9.3.6 RETRACTION

In the case that a sensitive mat fails (ECU does not receive the diagnosis signal or it always receives a true state of this signal), over-consumption of the motor or speed detection is detected before/during the retraction, the Bridge Plate will stop automatically. If a complete retraction is necessary, the “close command” signal must be kept activated until the Bridge Plate achieves the maximum retracting position. In this condition the Bridge Plate moves ignoring the environment (users etc.). The override is active while the “close command” is activated. When this signal is deactivated, the movement continues but the override characteristic is disabled and the obstacle detection is reactivated. The retraction can be executed without the enable signal. This situation is uneven because the “Bridge Plate enable” signal is disabled and the override is deactivated.

6.A.9.4. CUT OUT MODE

This operation allows the function of the Bridge Plate system to be completely canceled in case of fault to avoid any automatic movement. The Bridge Plate system can be mechanically and electrically isolated by turning the operation mode selector 1/4 clockwise from automatic operation. That turn will mechanically lock the Bridge Plate by means of a mechanical lock (as long as it is 100% retracted). At the same time, using the “Isolated switch”, the electronic control unit receives the signal that the Bridge Plate system has been isolated. The sequence to isolate the Bridge Plate system is the following:

- Retract the Bridge Plate (manually or automatically)
- Activate the isolation device (1/4 turn clockwise from automatic operation)

6.B. DESCRIPTION OF GENERAL ARRANGEMENT /FUNCTION OF DOOR SYSTEM

Please refer to chapter 6.A.2 et seq.

6.C. DESCRIPTION OF GENERAL ARRANGEMENT / FUNCTION OF BRIDGE PLATE

Please refer to chapter 6.A.8 et seq.

6.D. DESCRIPTION OF DOOR AND BRIDGEPLATE CONTROL CIRCUITRY AND CONTROL LOGIC

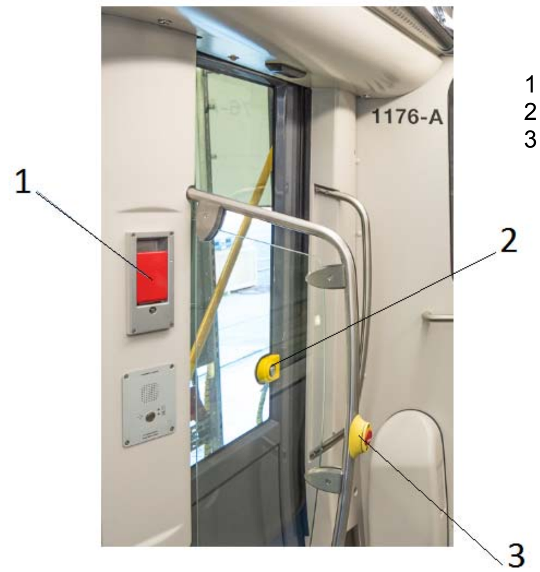
Please refer to chapter 6.A.10 et seq.

6.E. PUSHBUTTON ARRANGEMENT

Each door area is equipped with an exterior and interior passenger pushbutton, emergency egress device, and stop request pushbutton. The doors near the drivers cab are equipped with the emergency access device and the crew door switch.

The pushbuttons are installed at a height of approximately 1000 mm (39.37″) above floor level and approximately 800 mm (31.49″) above floor level. The emergency egress device is installed on the interior of the car, at a height of approximately 1445 mm (56.89″) above the floor level.

The emergency access device is installed on the exterior of the car, on the right hand side at a height of approximately 969 mm (38.15″) above the rail top. The crew door switch is installed on the left hand side approximately 1225 mm (48.24″) above the rail top.



1 Emergency Egress Device
2 Open Pushbutton
3 Passenger's Stop Request

Figure 9. Typical distribution of the interior Pushbuttons and devices.

The image above shows the typical distribution of the passenger push button and emergency devices of CAF's streetcars. The arrangement at the double-leaf doors has a similar provision to the single-leaf door.

The vehicle is equipped with a sufficient number of inner and outer bridge plate request pushbuttons. They are installed at a height easily reachable for persons with reduce mobility.

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Sub-Part A – VEHICLE DESCRIPTION

SECTION 7 HEATING, VENTILATION & AIR CONDITIONING REQUIREMENTS

7.A. HVAC SYSTEM DESCRIPTION

7.A.1. DESIGN

CAF's proposed HVAC system for the City is composed of three HVAC units that provide heating, ventilation, and air conditioning to the passenger compartment and the operator's cabs.

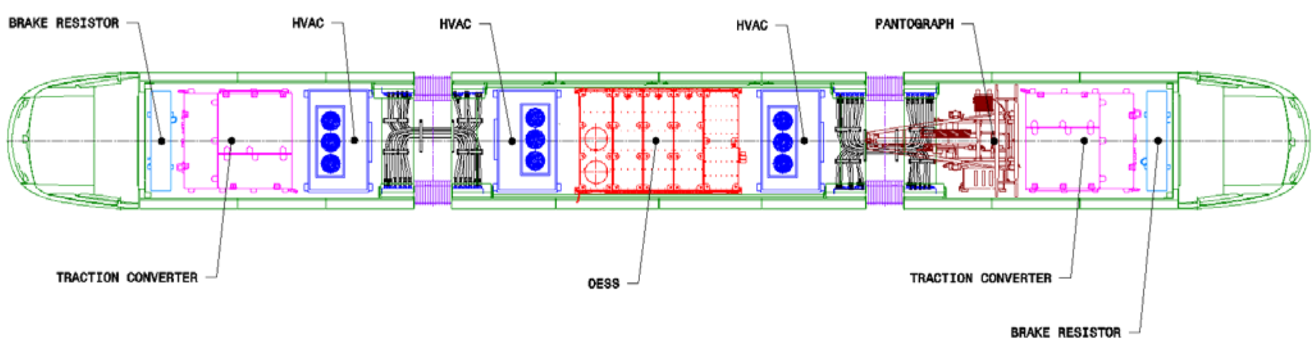

Figure 1. *HVAC units arrangement*

Cooling is accomplished by pulling air from the car interior through a horizontal return air grille into the return air plenum, where it mixes with filtered fresh air. The mixed air then passes through the mix air filter, evaporator coil assembly, and heater where it is cooled, dehumidified, or heated before it enters the blowers. The blowers pressurize the conditioned air and discharge it out of the bottom of the unit into the vehicle air-distribution ducts.

Each unit is controlled by a microprocessor located in an enclosure mounted inside the unit. The microprocessor controls the unit in order to maintain the set interior conditions. Communication between HVAC units and the car communication system is done via CAN Open bus.

The system is designed to operate with minimal preventive maintenance.

CAF works with several suppliers that could provide the solution described in this document.

7.A.2. MANUFACTURING

The units are self-contained, hermetically sealed, and roof mounted. Each unit contains two scroll compressors, operating two refrigerant circuits. One compressor cycles off for cooling capacity control. The A/C system is hermetically sealed.

Major components such as the evaporator blower/motor and condenser fan/motors are arranged for easy access and service from rooftop level. The evaporator compartment is insulated with acoustic foam. High temperature insulation is used in the heater area.

7.A.3. OPERATION

A microprocessor controller located in the unit interior controls each unit, as well as the communications with the other units. The microprocessor controls the unit to maintain the set interior conditions (customized curve) using different cooling/heating modes, performs safety and shutdown protection, self-diagnostics, and fault monitoring. The controller-enhanced function enables operation of the unit from a laptop, when connected. Three electronic solid-state sensors (fresh air, return air, and blower discharge air) are used.

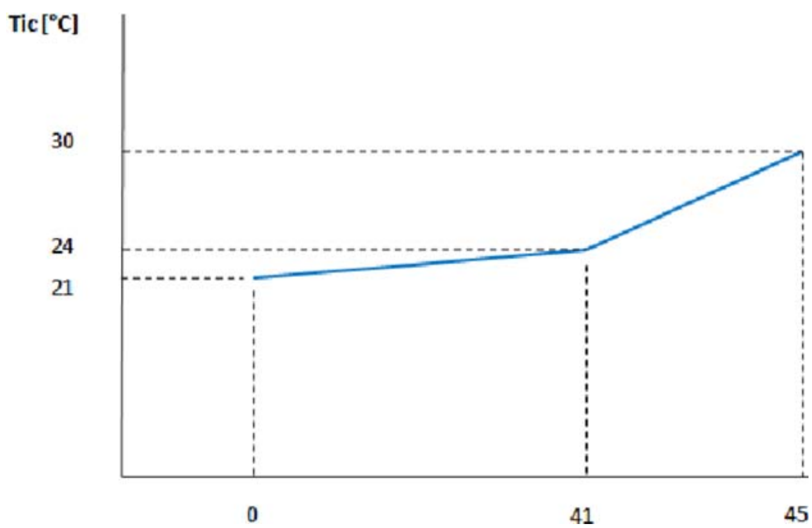

Figure 2. *Set point control curve (just for reference)*

The HVAC system is automatically activated whenever the streetcar is powered. The HVAC system will operate (cooling, ventilation, heating, defrosting, etc.) depending on the ambient temperature, the set point temperature, and the air return temperature, as shown in Figure 3.

HVAC SYSTEM
LRV TEMPERATURE CONTROL

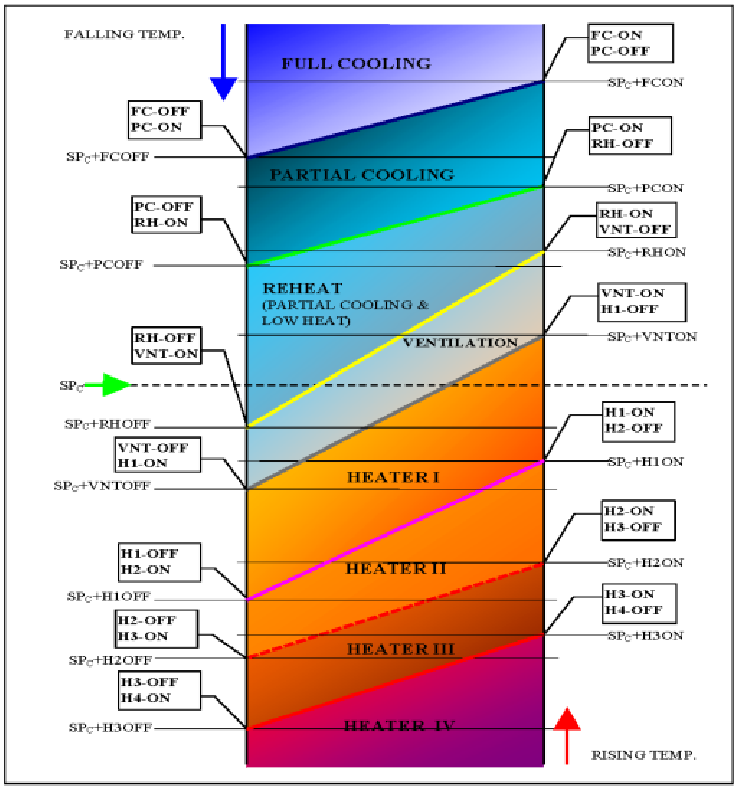

***Figure 3.** Temperature control diagram*

A 32-bit microprocessor-based controller located in the unit interior controls each unit and communication to other units. The microprocessor controls the unit to maintain the set interior conditions (UIC curve or customized curve) using different cooling/heating modes, performs safety and shutdown protection, self-diagnostics and fault monitoring. Controller enhanced function enables operation of the unit from a connected PC. Three (3) electronic solid-state sensors (fresh air, return air, and blower discharge air) are used.

There is software anti-freeze protection monitoring minimum supply air temperature that is allowed 46.4°F at full cooling and 44.6°F at partial cooling mode. Below these limits the unit switches into ventilation mode until the supply air temperature rises.

There is software-based high duct temperature protection monitoring maximal supply air temperature up to 140°F. Upon reaching this limit the unit switches into ventilation until supply air temperature drops.

7.A.3.1 COMPRESSOR PROTECTION

A low ambient lockout (at 40.1ºF) is activated by the ambient sensor. Motor over-current and over-temperature protection is also provided.

7.A.3.2 SAFETY DEVICES

- A check valve is built into the scroll compressor discharge to prevent refrigerant from flowing back to the compressor after shutdown.
- Circuit breakers/fuses and overload relays interrupt power to motors and heaters in the event of overload and short circuits.
- Current transformers are used to monitor (max/min) amps to protect components during overload and interrupt control circuits in the event of low airflow to heaters, and overall system logic.
- Relief valve installed on the high side to protect against rupture.
- High and low pressure switches are used to shut compressors off if abnormal pressure occurs.
- Modulation pressure switch reduces system capacity under load conditions approaching the high-pressure switch limits.
- Heater automatic high limit switch prevents excess temperature build up during abnormal conditions
- Software interlock prevents activation of heaters and compressors when evaporator blower motor is de-energized.

7.A.4. PERFORMANCE

Each of the three HVAC units has a nominal cooling capacity of 20 kW and 13 kW of heating capacity, providing 60 kW of cooling capacity and 39 kW of heating capacity in total.

7.A.5. BASIC SYSTEM CONFIGURATION

Components	No.	Components	No.
Fully Hermetic (Scroll Compressor)	2	Evaporator Blower Wheels:	2
Condenser Fans:	3	Thermal Expansion Valves:	2
Condenser Coils:	1	Solenoid Valve:	2
Refrigerant Receiver:	2	Evaporator Drain Pan:	1
Refrigerant Filter Drier:	2	Refrigeration Piping:	AR
Liquid Line Sight Glass/Moisture Indicating:	2	Insulation:	AR
Discharge Check Valve:	2	Structural Frame & Housing:	1
Suction/Discharge Vibration Eliminators:	4	Air Filters:	2
Unit Isolator:	4	Overhead heater:	1
Suction Line Insulation:	AR	Control Boxes:	1
Evaporator Coil (four rows deep):	1	Micro Controller and Controls Concept:	1

The proposed HVAC system is designed to provide improved accessibility for maintenance, and will operate at full capacity up to condenser air. Beyond 111ºF (44ºC), the system will shift into modulation (part load) and will operate up to 125ºF (52ºC) condenser air before shutdown in the modulation mode.

7.A.5.1 ROOF-MOUNTED UNITIZED HVAC UNIT

- Fully Hermetic TK/Copeland Compliant Scroll Compressor: 2

  Two (2) TK/Copeland scroll compressors are provided for each HVAC unit. One compressor will be cycled off for capacity control. The entire compressor assembly is removable as a unit. The compressors are equipped with over temperature and over current protection. The compressors are set up for 460 VAC / 3Phase / 60Hz.

- Condenser Fans: 2

  Two (2) propeller fans with bell mouth orifice and taper lock bushing operating at 1720 RPM pulls air across the condenser coils. Hub epoxy coated with stainless steel hardware.

- Condenser Coils: 2

  Epoxy gold coated aluminum wavy fin, copper tube coil. Fins are .006" thick, with 10 fins/inch. Inner grooved tubes are .32” O.D. x .016" wall. Coil casing and end supports are aluminum. The subcooler is an integral part of one condenser coil.

- Condenser Fan Motor: 2

  Double speed, 460 VAC / 60Hz / 3Phase, 1.5HP (1.125 kW) at 1720 RPM, totally enclosed air over, Class F insulation treated to be impervious to moisture. Bearings are permanently lubricated rolling type. Motor is equipped with over temperature protection.

- Refrigerant Receiver: 1

  Steel shell with soldered inlet and outlet connections. Tank is sized to insure sub-cooled liquid head to thermo expansion valves.

- Refrigerant Filter Drier: 1

  One-piece inline solder type filter-drier with 100-mesh inlet screen. Rated at 125.6ºF (52ºC) (490 drops)

- Liquid Line Sight Glass/Moisture Indicating: 1

  The sight glass is located in the liquid line prior to TXV and visible from return air plenum.

- Discharge Check Valve: 2

  The check valve is an integral part of the compressor to prevent refrigerant from flowing back to the compressor when the system is off.

- Suction/Discharge Vibration Eliminators: 4

  Vibration eliminators are provided in the compressor suction and discharge line to minimize transmission noise and vibration along interconnecting tubing.

- Unit Isolator: 8

Eight (8) Unit isolators will be provided to reduce vibration transmission to car structure

- Suction Line Insulation: AR

  Suction line is insulated with fire-retardant, closed-cell K-Flex Eco

- Evaporator Coil (5 rows deep): 1

  Hydrophylic coated aluminum wavy fin, copper tube coil. Fins are .006 inches thick, 10 fins/inch. Inner grooved tubes are 3/8" x .016" wall. The coil casing and end supports are aluminum.

- Evaporator Blower Wheels: 2

  Two (2) single inlet heavy-duty R-Series steel wheels provide 2350 ft3/min (4000 m3/hr) airflow to the car duct system.

- Evaporator Motor: 1

  Single speed, double shaft 460 VAC / 60Hz / 3phase, 1720-RPM motor, 4.0 HP (3.15 kW) totally enclosed air over, class F insulation. Bearings are permanently lubricated, rolling type. Motor has over-temperature protection. Assembly is balanced per AMCA and NEMA standards.

- Thermal Expansion Valves: 2

  Solder type thermal expansion valves with externally adjustable superheat, external equalizer and remote bulb. Brass refrigerant distributor is located on the evaporator coil assembly.

- Solenoid Valve: 1

  One solenoid valve per refrigerant circuit.

- Evaporator Drain Pan: 1

  One stainless steel drain pan with internal baffle and edge lips to minimize sloshing and overflow of condensate. Pan is insulated with closed cell K-Flex Eco to prevent sweating of outside surfaces. Drain pan connections are 25 mm (outside diameter).

- Refrigeration Piping: AR

  All refrigerant piping except for the coil tubing is Type K seamless copper. Polypropylene tube clamps are used to support tubing.

- Insulation: AR

  Evaporator compartment is insulated with K-Flex Eco. Fiberglass is used in the heater area.

- Structural Frame & Housing: 1

  The main structural is manufactured from stainless steel, outer housing aluminum.

- Air Filters: 3

  Three (3) filters, two pre-filters G2 (MERV 4) and filter G4 (MERV 8), are provided filtering of the fresh air and mix air

- Overhead heater: 1

One (1) overhead heater with two stages 10 + 10 kW, 460 V AC is installed in the unit. Heating elements are double insulated type or open wire type.

Fresh Air Damper: 2

Two (2) On/Off Fresh Air dampers will be installed in the Fresh air intakes.

- MVB Card: 1

  One (1) MVB card will be provided for one HVAC unit.

- Main Control Box: 1

The contactor/control panel is contained in a single mechanically separated control box. The control box is mounted inside the unit. The contactor portion contains all the necessary motor contactors, relays, overloads and circuit breakers of heavy-duty industrial grade suitable for transportation service. The control panel provides mounting for the microprocessor. A three position (test, off, and auto) test switch is mounted externally. Earthing ground located on unit frame.

Connectors – Harting Type for low voltage connectors with pins are mounted on the front side of the unit. Harting Type connector for high voltage (208 V AC) is mounted outside the unit.

- Micro Controller and Controls Concept 1

Micro-processor-based temperature controller provides system control, fault monitoring, and diagnostics.

The micro-controller is a transport industry temperature controller for self-contained refrigeration or HVAC systems. The equipment is used for a wide variety of applications.

The controller regulates the temperature in the car through multiple operating modes. These operating modes are determined by the system configuration, analog input values, digital input states, and the system set point. Set point per UIC curve or customer curve, (figure 3), is a function of ambient temperature.

The HVAC microcontroller provides the following functions:

1. Control per customer requirements
2. Safety and shutdown protection
3. Diagnostics
4. Fault monitoring and annunciation
5. Self health check
6. Sequential starting of motors and units
7. The unit operation can be monitored by connecting a laptop computer.
8. A RS232 DB9 female interface connector mounted inside the unit accessible from the return air opening for monitoring system performance and fault conditions.

- Portable Test Unit

HVAC controlling software will be provided:

1. Access via a serial port located in return air opening SUB D (9-pin) connector RS 232 or service port could be installed in car interior via low voltage connector X11. (max. cable length form X11 is 26 ft)

2. The supplier will provide software for the PTU.

3. Using a PTU, an operator can perform the following actions:

- Observe unit operating status
- Observe faults
- Manually initiate any mode
- Observe temperature of any sensor
- Initiate or cancel maintenance alarm
- Initiate self check
- Initiate automatic HVAC cooling/heating check

7.A.6. AIR DISTRIBUTION

The conditioned air will be distributed from the HVAC units to the air diffusers by means of a single duct, as shown in the figure below. The duct will be continuous throughout the entire vehicle, including the articulations.

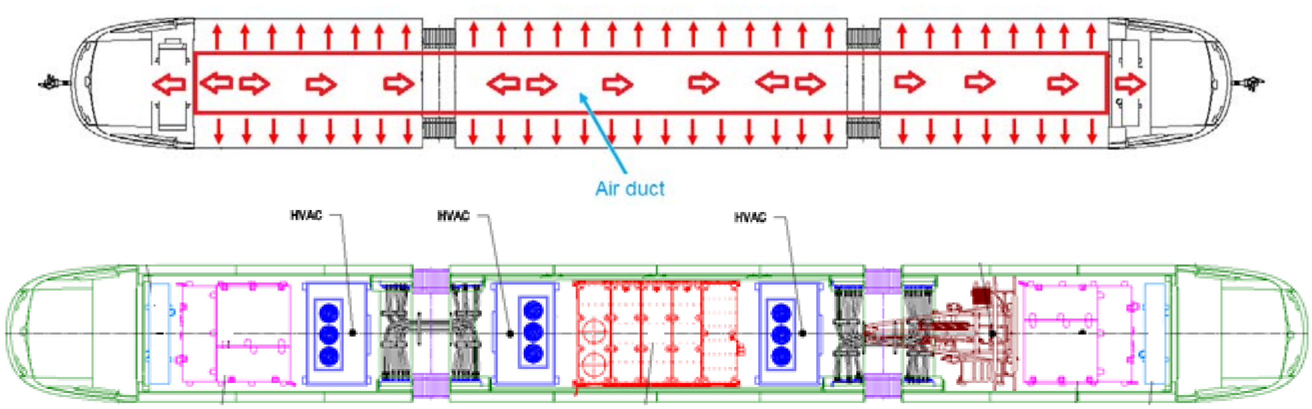

Figure 4. *General arrangement of the HVAC unit and ducting*

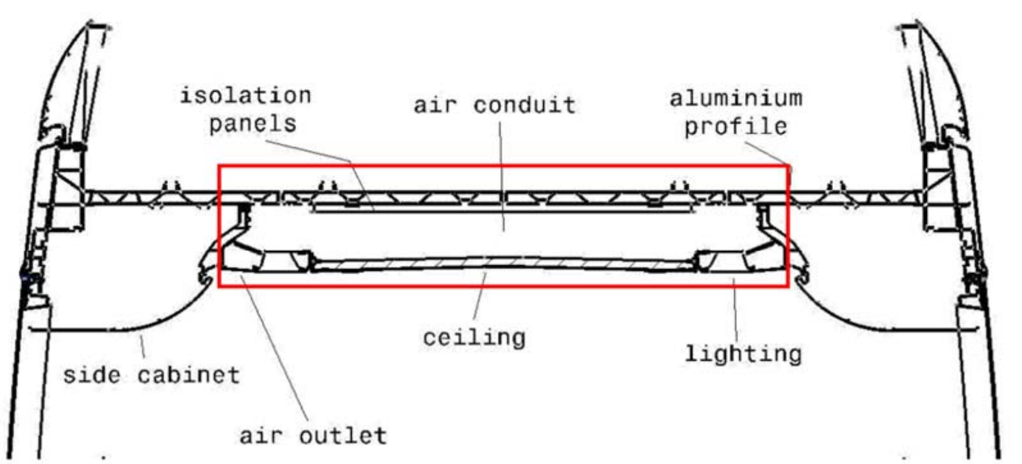

Figure 5. *Air Duct Cross Section*

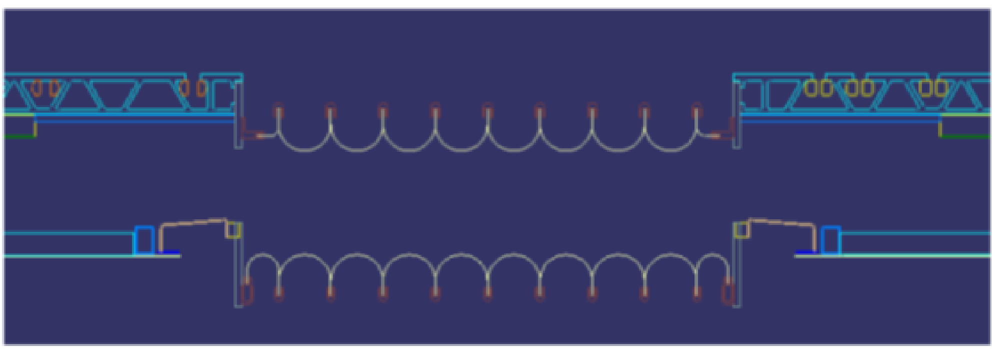

Figure 6. *Articulation connection section*

Air will be discharged into the passenger compartment through the left and right air diffusers.

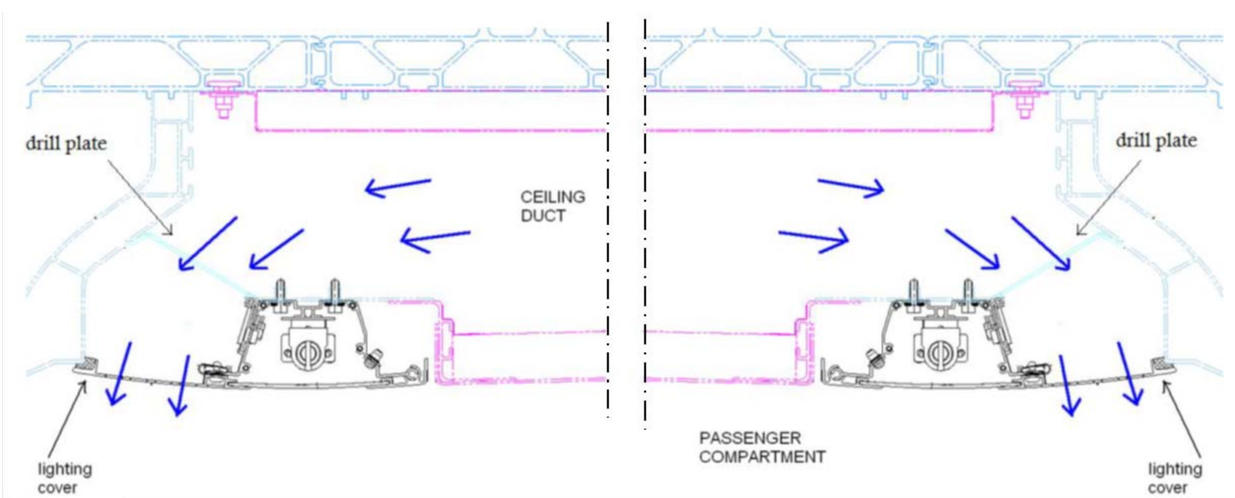

Figure 7. *Cross section air outlet*

7.A.7. CAB AIR DISTRIBUTION

Conditioned air flows into the cab module from the passenger area duct through a large opening in the cab partition. Inside the cab module, the air is conducted by a cab duct to the following outlets:

- Front windshield (upper area) to defrost the windshield and to reduce solar radiation
- Sides to cool or warm the cab

There is an electrical air damper inside the cab duct to control the air passage. The damper is actuated from the operator's console.

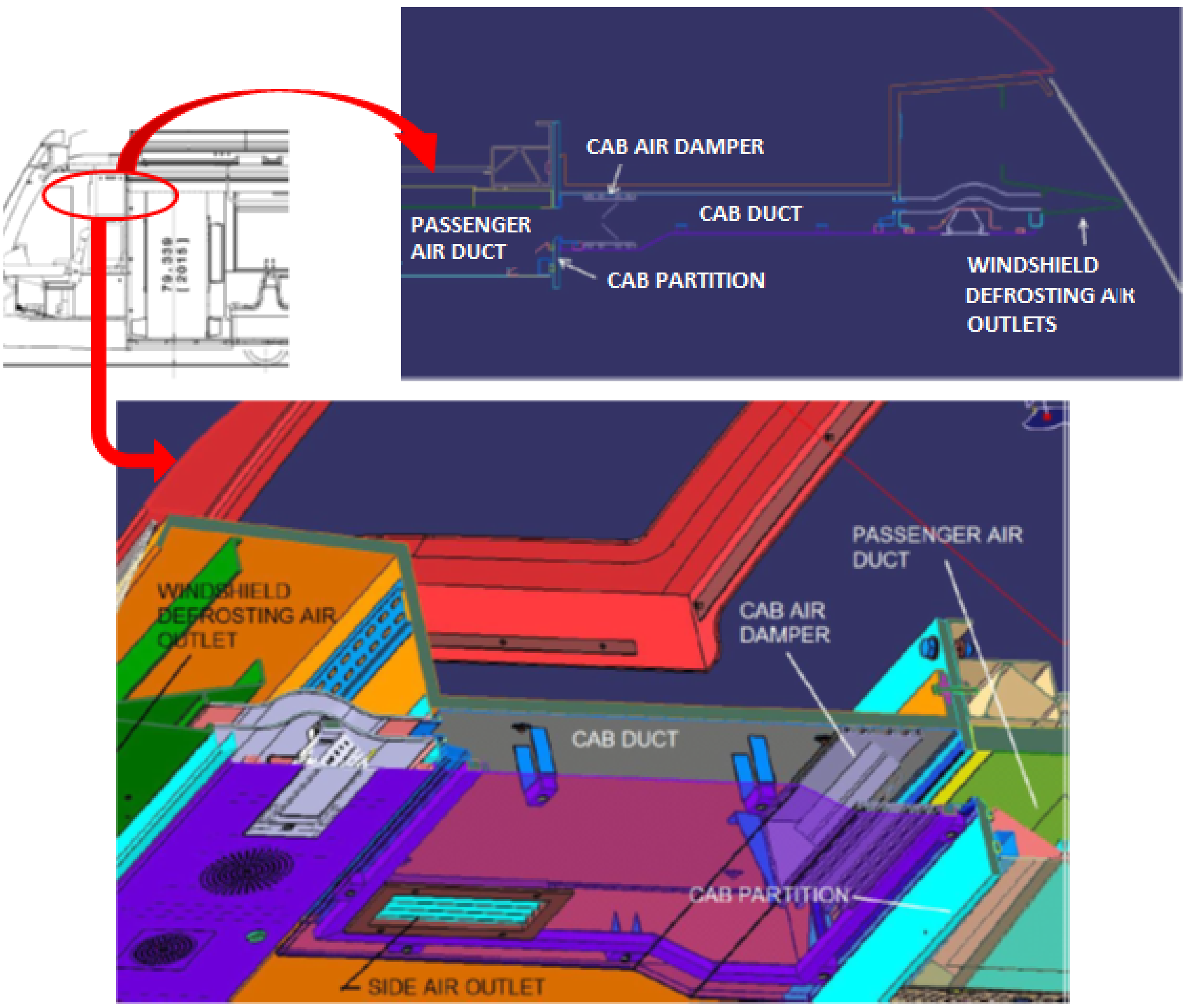

Figure 8. Cab air input and distribution

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SECTION 8 LIGHTING SYSTEM REQUIREMENTS

8.A. LIGHTING SYSTEM DESCRIPTION

8.A.1. BASIC SYSTEM CONFIGURATION

All lighting will be LED except for the Headlights.

8.A.2. INTERIOR LIGHTING

The passenger area is illuminated by two longitudinal rows of LED fixtures mounted in the ceiling above the seats and LED clusters lights at each rear end.

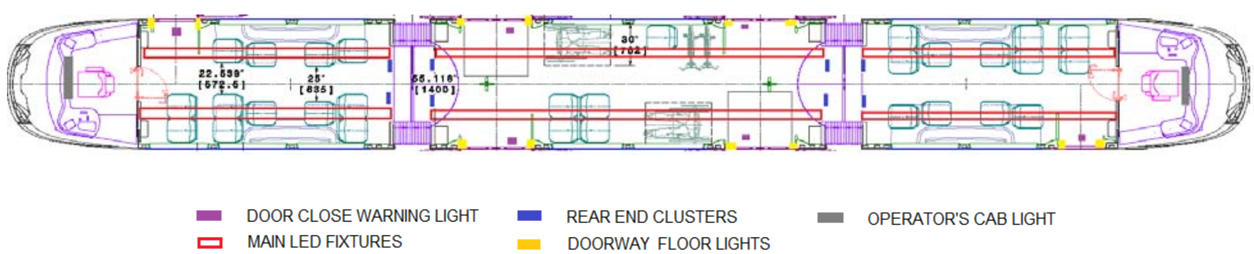

Figure 1. *General lighting arrangement.*

The longitudinal fixtures are held in place with screws to extruded aluminum profiles. Access to the LED cards is via hinge covers.

The main interior lighting is turned on whenever the car auxiliaries are turned on by the master controller key switch. The LED light fixtures are operated from the low voltage power supply, with some connected to the Emergency Circuit.

Lights are wired on four circuits; one normal operation for the right row, another normal operation for the left row, one normal operation for rear end clusters and one emergency operation. Each circuit is fed through a separate circuit breaker.

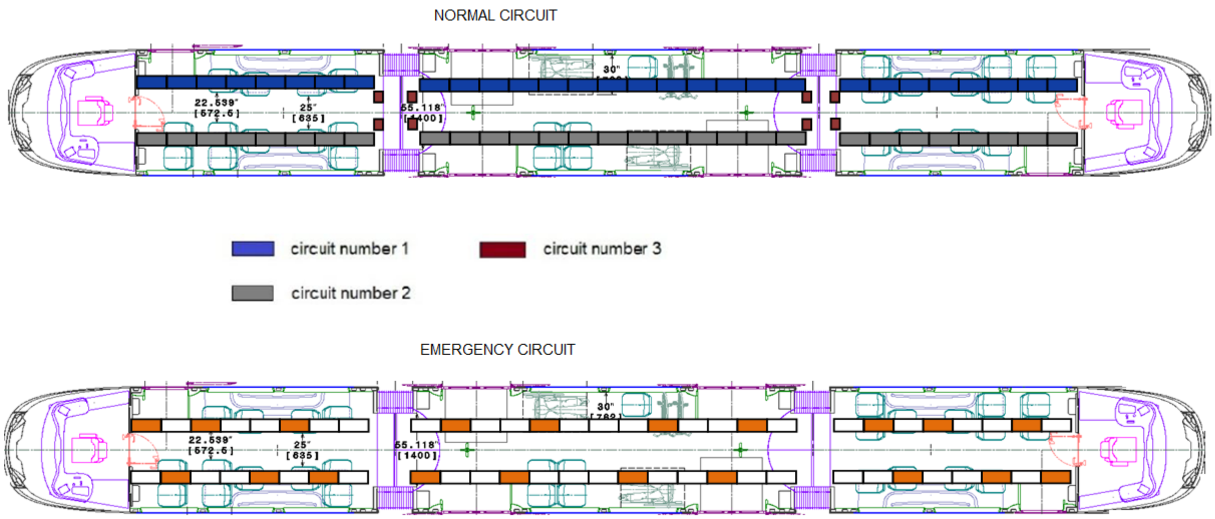

Figure 2. *Lighting Circuits*

The lighting circuits remain on when primary power is momentarily lost, such as when the car is going through a non-bridging isolator. If power is lost for an extended period, only emergency lights shall remain on.

LED cluster lights are provided at each doorway for threshold and platform illumination.

Cabs are provided with a LED Cab Light fixture in the ceiling powered from the LVPS as general lighting during normal operation.

Cabs are also provided with an LED Console Light fixture powered from the LVPS to enable the operator to see the console labels, pushbuttons and switches under varying lighting conditions.

The door warning indicator will consist of an LED cluster with an amber polycarbonate lens. The fixture will be mounted above each door cabinet inside the vehicle.

These indicators will be mounted in a position that makes them visible from both inside and outside the car. The dome shape lens allows the lamp to be viewed from multiple angles.

The door warning indicator will be powered from the LVPS.

8.A.2.1 LIGHT FIXTURES

8.A.2.1.1 PASSENGER AREA MAIN LIGHTING

The main light in the passenger area for modules C1 and C2 is made up of two light fixtures of 181.7 inches (4,615 mm) length.

The main light in the passenger area for module S is made up of four light fixtures of 141.7 inches (3,600 mm) length.

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The fixture housing is constructed of anodized aluminum extrusion.

Construction is dust and moisture proof.

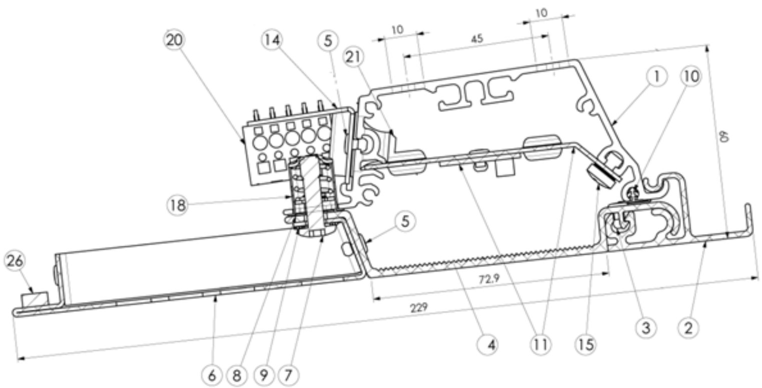

Figure 3. *Section detail of the main passenger light fixture*

8.A.2.1.1.1 LED CARDS

The light fixtures of 181.7 inches (4,615 mm) length are composed by 7 LED cards 23.6 inches (600 mm) length and 1 led card 17.7 inches (450 mm) length.

The light fixtures of 141.7 inches (3,600 mm) length are composed by 6 LED cards 23.6 inches (600 mm).

The color temperature of the LED cards is 4000 K.

The LED cards are powered from the LVPS, and can operate continuously between 16.8 Vdc and 32 Vdc.

Safety grounding of LED cards and fixtures is isolated from the power return.

Reversing polarity on the LED card does not result in damage to the module.

The LED cards have an over-temperature protection sensor which automatically resets when the temperature drops to acceptable levels.

8.A.2.1.2 ACTIVE DIMMING

The main target of the Active dimming is to keep the light levels constant inside the vehicle during the daytime by decreasing the normal lighting inside the vehicle when daylight is available.

Energy saving is achieved by automatically dimming the lights off in daylight conditions. The lights will automatically activate when driving through a tunnel or other dark condition keeping a predefined illumination level in the compartment.

The lifetime of a LED is strongly dependent on its operating temperature and by implementing active dimming it can be considerably extended.

8.A.2.1.2.1 LIGHT SENSORS

Two light sensors inside the vehicle measure the light levels. Active dimming control unit takes the average measure of these sensors.

Light sensors are placed inside the vehicle, both front and rear areas, on C cars. They are assembled to the interior ceiling of the cars, so the light sensors can measure the light levels inside the vehicle and the direct light flow from the lighting fixtures to the light sensors is avoided.

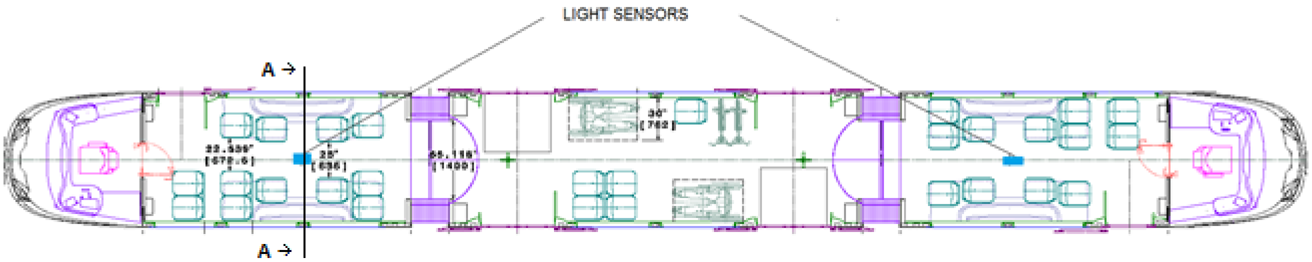

Figure 4. *Light sensor layout*

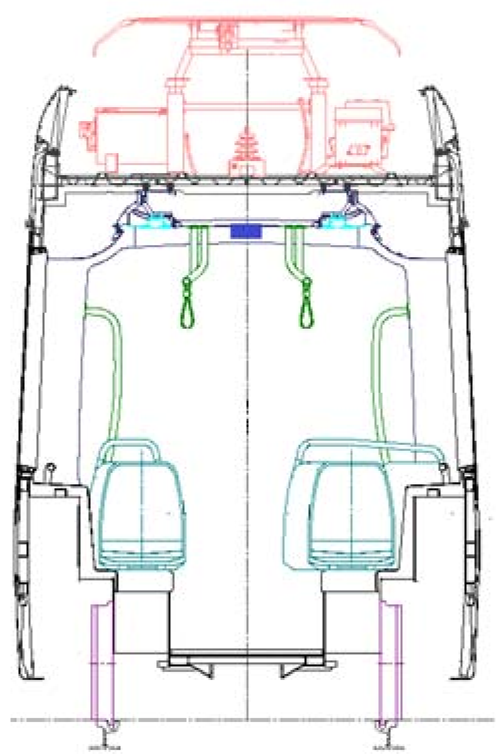

Figure 5. *Light sensor (detail A)*

8.A.2.1.2.2 ACTIVE DIMMING CONTROL UNIT

The control unit is assembled inside the side cabinets in the S car.

The control unit is powered from LVPS at 24 Vdc.

8.A.2.1.3 ARTICULATION LIGHTING

As part of the main interior lighting, two LED cluster lights are provided at each rear end for the articulation illumination. They are attached with screw to the upper lining.

The articulation lighting is powered from the LVPS at 24 Vdc and turn on/off with the main lighting. It is not wired into the emergency light circuit. The articulation lights are also controlled with the active dimming control unit.

8.A.2.1.4 DOORWAY FLOOR LIGHT

LED cluster lights are provided at each doorway for threshold and platform illumination. The LED clusters are located in the lower area of both door pillars.

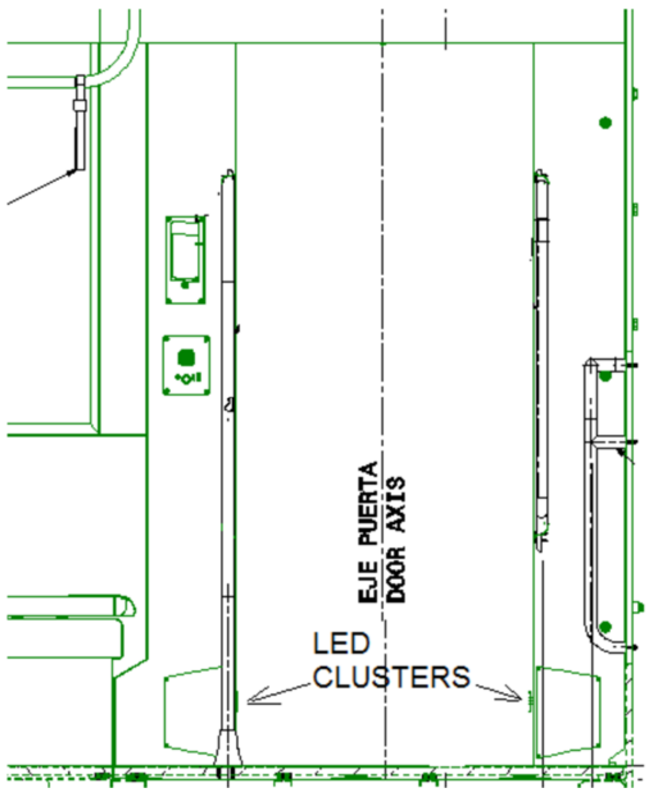

Figure 6. *Doorway floor lights (left, section view / right, front view)*

The lights are illuminated when the passenger door starts to open and are extinguished when the door is closed and locked.

8.A.2.1.5 OPERATOR'S CAB LIGHTING

Each cab is provided with a LED light fixture powered from LVPS. It is suitably placed in the ceiling to illuminate the operator's console.

The light beam does not produce glare on the windshield.

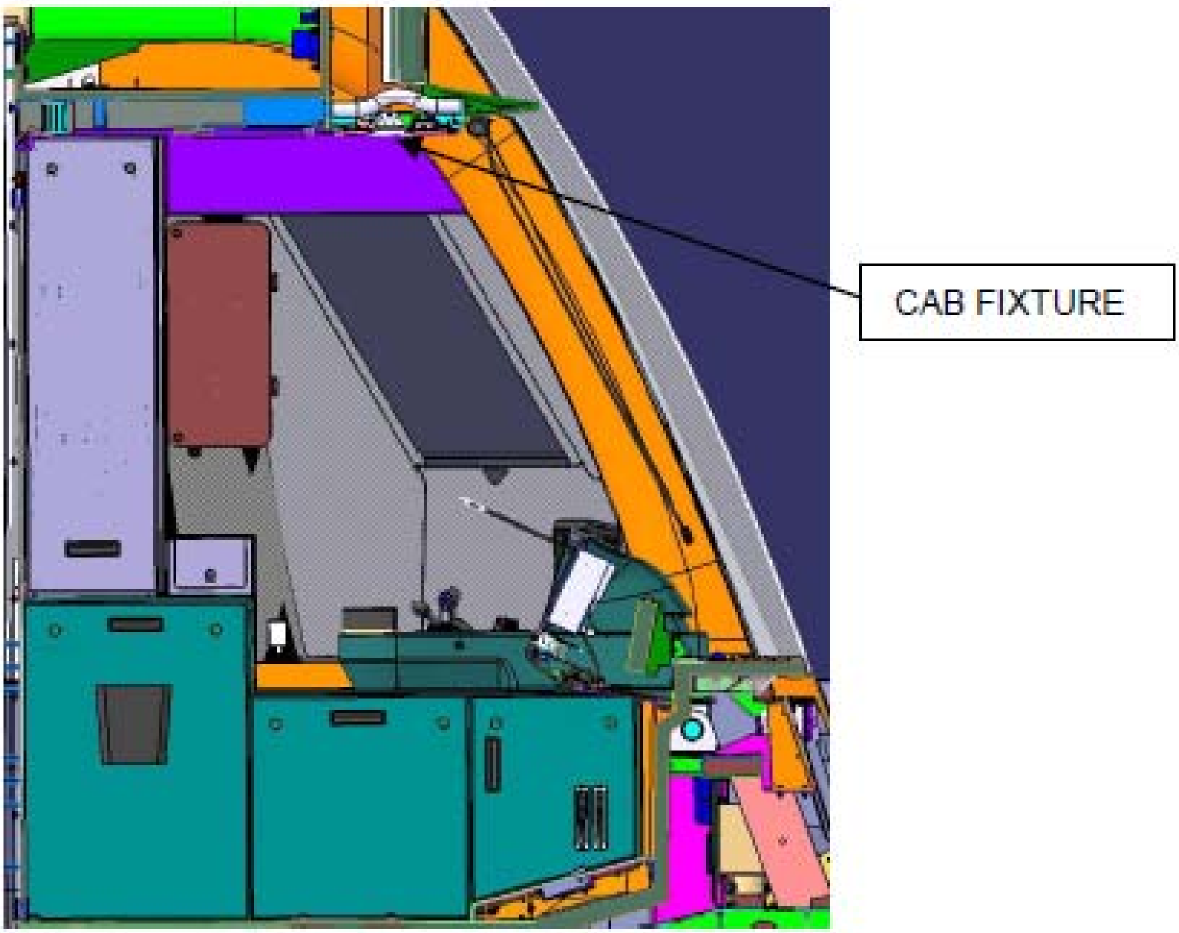

Figure 7. *Cab section showing the cab fixture and the operator's console*

The door assembly includes a polycarbonate translucent lens with a sheet metal frame. The assembly with the body is made by two screws, allowing easy opening of the door.

The LED card is attached to the body with rivets.

The cab light is controlled from a rotary switch on the operator's console which turns the cab light on/off. The cab light functions only when the cabin is active. At all other times, the light is extinguished.

8.A.2.1.6 CONSOLE LIGHT

Each cab console is illuminated with three LED strips to enable the operator to see the console labels, pushbuttons and switches under varying lighting conditions.

The console light is mounted with screws on the top edge of the console and shielded from the operator's eyes. When illuminated, the console light does not cause glare on the windshield.

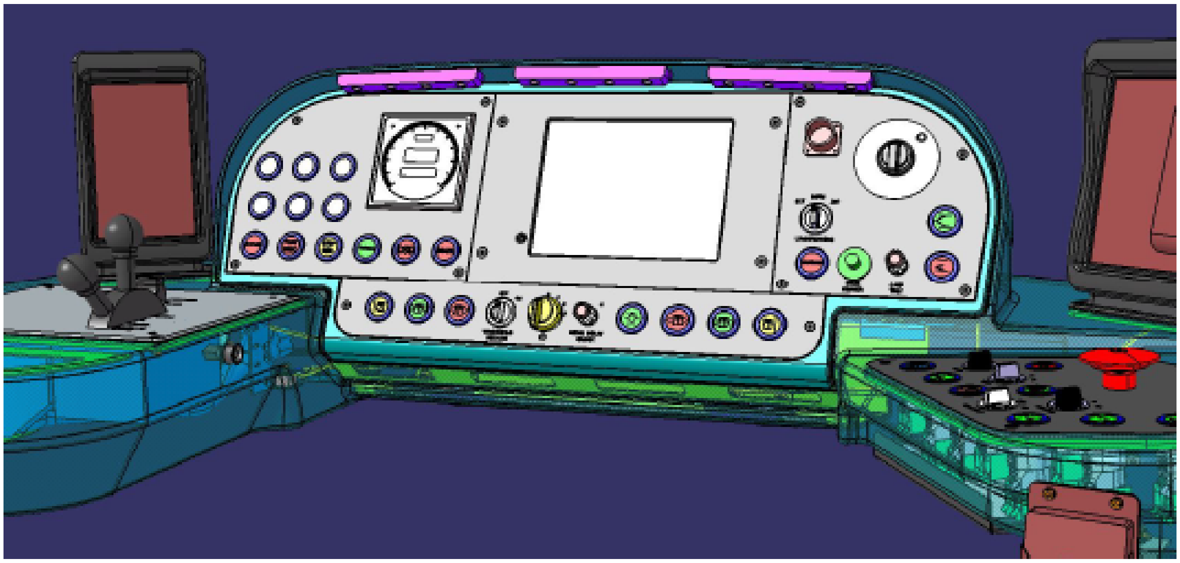

Figure 8. *Operator's console with console lights at the top edge*

The console light is energized automatically when the operator's console is powered. The console light is dimmed by a rotatory control on the console, when it rotates, the intensity of the console light can be increased or decreased.

In the minimum position, console light is switched off.

8.A.2.2 LIGHTING CRITERIA

The average intensity of the illumination within the car, at an elevation of 33 to 66 inches (840 to 1670 mm) above the floor, shall be at least 30 lumens per square foot (320 lux), at 24 Vdc.

The average light intensity at the floor in the passenger aisles and articulation section shall not be less than 20 lumens per square foot (215 lux).

The average light intensity at the car entrances and exits within 20 inches (500 mm) of the doors shall not be less than 20 lumens per square foot (215 lux) at the floor. The light entrance will provide not less than 5 lumens per square foot (54 lux) of illumination measured on the surface of the platform 3 ft (900 mm) away from the vehicle side in the horizontal direction.

The average illumination intensity measured on the operator's controls shall be at least 30 lumens per square foot (320 lux).

Lights levels will be confirmed after the light simulation, but our experience with earlier Stockholm projects shows that the proposed light units fulfill the required light levels. The light simulation report shall be provided for the City's review and approval.

8.A.3. EXTERNAL LIGHTING

The external lighting of the streetcar remains on and switches automatically depending on the direction of travel while the cab is active.

The warning hazard lights are supplied directly by the battery, so they are always operational, even when there is no active cab in the streetcar or when the isolation battery switch is operated.

In order to minimize electrical consumption in the streetcar and to maximize the life of the components, LED external lights are proposed for the external lights, except for the headlights.

The white headlights lamp combines both low-beam and high-beam lights. The electric circuits of the streetcar ensure that only one of them is used at any given time.

Red tail lights and brake lights are combined in the same lamp. A clear distinction between them is made as the brake lights have a greater light intensity than the tail lights.

Direction indicator lights are located on the front wall and on the side walls.

Marker lights, one amber, and one red, are located near each end corner of the vehicle.

The streetcar will be fitted with external lights as shown in the following figure:

Figure 9. *External Lighting*

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SECTION 9 AUXILIARY ELECTRICAL EQUIPMENT REQUIREMENTS

9.A. AUXILIARY ELECTRICAL EQUIPMENT DESCRIPTION

9.A.1. NARRATIVE PROPOSAL

The auxiliary electrical equipment is designed to provide all the required power to the low and medium voltage loads. The function of the battery charger is to supply the required power to the train's batteries, according to their characteristics.

The auxiliary power supply (APS) and battery charger are installed in the same box as in the traction converter, and are powered directly from the catenary high voltage connection.

Regarding the redundancy level, the auxiliary power supply is redundant in the following scenario: in case of failure of one of the APS, all the train AC loads will continue being powered normally, except the HVAC cooling system which will be reduced by a 50% output level.

The battery charger is totally redundant; in case of failure of one of the battery chargers, the other one can provide all the required power to the rest of the train.

The following figure shows a schematic of the power circuit of the streetcar with its main components:

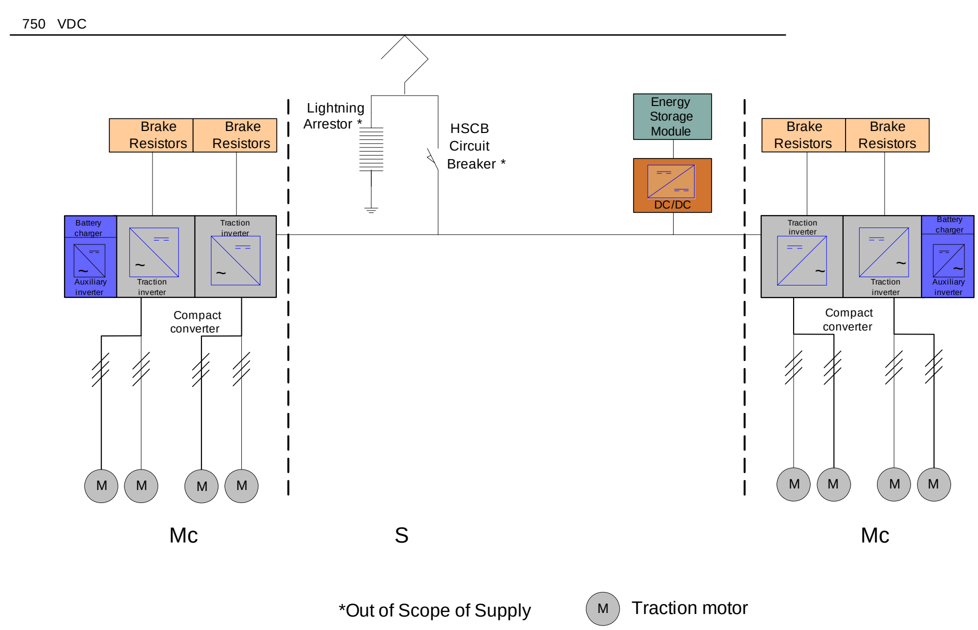

Figure 1. Overhead power collection System

9.A.2. AUXILIARY ELECTRICAL EQUIPMENT

9.A.2.1 AUXILIARY POWER GENERATION AND DISTRIBUTION BLOCK DIAGRAM

AC loads block diagram:

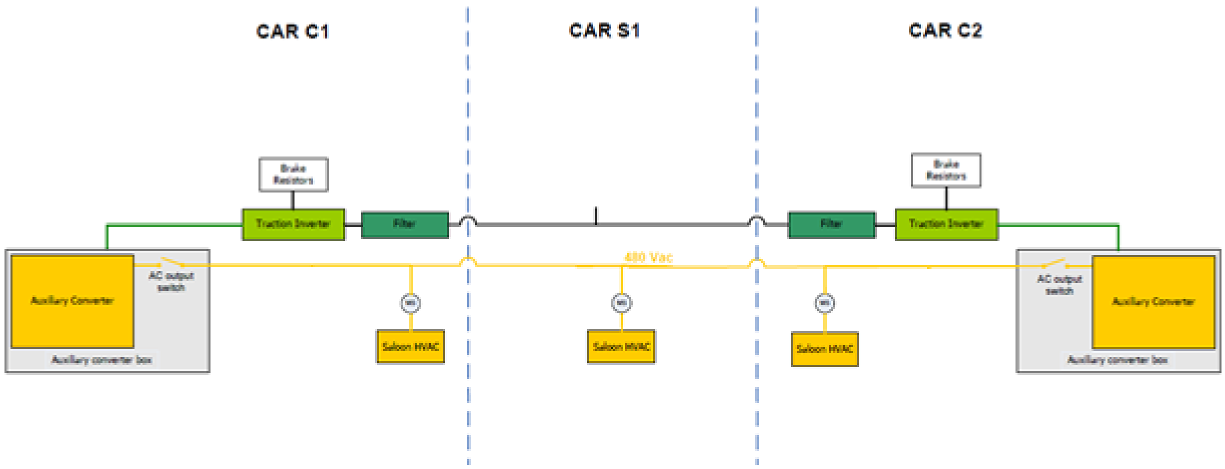

Figure 2. AC loads diagram

DC loads block diagram:

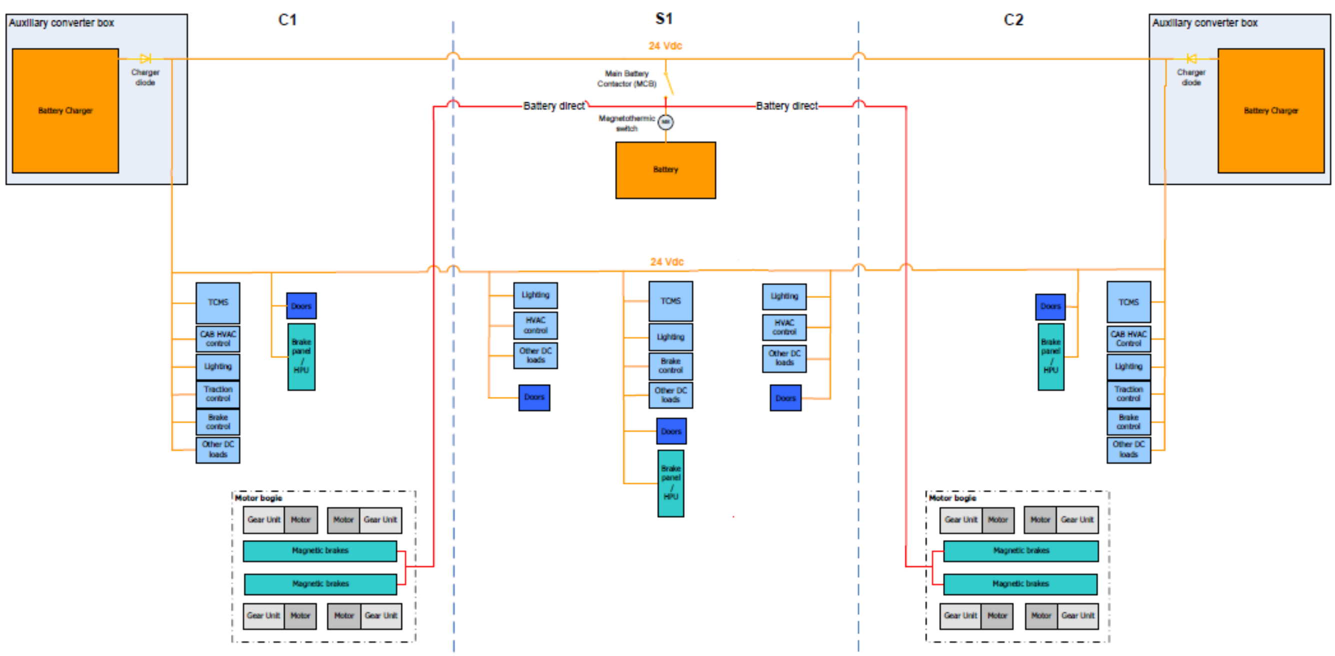

Figure 3. DC loads diagram

9.A.2.2 AUXILIARY POWER SUPPLY DESCRIPTION

Each power converter box (two per vehicle) is equipped with an auxiliary converter and a battery charger, providing the necessary power to the auxiliary equipment.

The auxiliary converter is responsible for supplying power to the auxiliary equipment (battery charger, compressors, fans, etc.), while the battery charger supplies the low voltage required power to the streetcar equipment, including batteries, according to their characteristics.

Therefore, each power converter contains, in a single compact box (aluminum riveted enclosure one): two independent traction inverters, one completely autonomous auxiliary converter and one battery charger. This configuration allows for better use of the available space and weight optimization. The auxiliary converter is a completely autonomous converter with galvanic isolation between the high voltage and the low voltage sides.

The function of the battery charger is to supply the required power to the train's batteries, according to their characteristics. The battery charger is made of a rectifier, an IGBT-based converter with galvanic isolation, an output filter and the necessary control electronics with a microprocessor.

Both the auxiliary power supply and battery charger run a system check up on every start up to assure correct functioning. Any failure detected will be shown to the driver via the HMI of the cab. It will also be possible to download a log with the record of all the failures and operation alerts of the system.

9.A.2.2.1 TECHNICAL AND PERFORMANCE DATA

Characteristics of the auxiliary converter and battery charger	
Input	
Input voltage	750 Vdc
Voltage variations	525 V - 925 V (1000 Vdc during 5 minutes) According to IEC-60850
Three phase output (208 Vac)	
Output voltage	208 (3 phases + neutral)
Rated power	50 kVA[1]
Wave	Sinusoidal
Single phase output (120 Vac)	
Output voltage	120 V (phase + neutral)
Frequency	60 Hz
Rated power	3 x 1.8 kVA

[1] Auxiliary converter is designed to deliver a maximum power of 50 kW permanently, including three and single phase output and battery charger output.

9.A.2.2.2 LOAD SHEDDING

Each converter and battery charger has been designed taking into consideration the most critical situation:

- All low voltage loads.
- Maximum power consumption considered for each load.

In case of failure of one auxiliary converter or battery charger in the vehicle, the other converter/charger will supply the vehicle's loads with some load shedding, so that the vehicle may return to the depot under its own power.

- 50% of the air conditioning and 46% of the heating in passenger compartments for are shed under the power of a single auxiliary converter.

9.A.2.3 LVPS LOADS

The following table shows the loads connected to the Low Voltage Power Supply (LVPS).

LOADS	Unitary Powers (W)
LIGHTING	
Cab lighting (fluorescent 36 W)	42
Emergency passenger lighting (fluorescent 58 W)	136,875
Normal passenger lighting (fluorescent 58 W)	157,5
Headlights	35
Tail / Stop lights (led)	10
Front outline amber marker light - (leds)	10
Rear outline red marker light - red (leds)	10
Front emergency lights / turning lights	1,5
Side emergency lights / turning lights	21
Side outline marker light - amber (leds)	0,2
Doorway floor lights	6
POWER	
Compact power equipment	294
High Speed Circuit Breaker	70
Pantograph	312
HVAC	
Passenger HVAC control electronics	100
BRAKE EQUIPMENT	
ECU	65
HCM	72
EHU	40
EHU (pumps)	1100
Safety brake electrovalve	22
Magnetic Track Brake	789,6
PASSENGER ACCESS DOORS	
Door electronic control	25
Door open / close	140
Maximum consumptions (opening/closing)	440
TRAIN CONTROL SYSTEM	
CCU-BA-GW	4,1
Input / output modules	30
Man Machine Interface	30
DCM	10
OTDR	
OTDR	26,5
Speedometer	5
PISPASPA	
PIS-CCTV Control Unit	150
Intercomm	3
External Front Indicator	39
External Side Indicator	39
Internal Display	25
Cab microphone (incl. Pre-amplifier)	1
Cab speaker	1
Passenger loudspeaker	1
External loudspeaker	5
CCTV	
Internal camera	3
Forward facing camera + heater	23
Rearview camera + heater	23
Rearview monitor	35
Ethernet switches T1 & T2	10
CITY EQUIPMENTS	
People counter (single door) - APC + Antenna WiFi	6
People counter (double door) - APC + Antenna WiFi	6
IVLU (Central SAE City) + DC-DC a 13.7Vdc	60
MDT (Mobile Data Terminal-Console)	20
Radios + antennas	35
APC network swtiches	2,4
Farebox (eq. Cliente)	15
OTHER EQUIPMENTS	
Windscreen washer	52
Horn	310
Bell	40
Pneumatic compressor	820
ELECTRICAL DEVICES	
Relays	3,7
Contactors	5,4

The following coefficient of use has been considered:

- Lighting and other cab devices: 50% of use, as lights are only connected in active cab
- Pantograph: 0.056%, connected four times (raised and lowered twice) for 10 seconds every 20 hours
- Brake pumps: 2%, run 5 seconds each 4.5 minutes
- Track brakes: 1.7% (ON for 20 seconds at end of each 20-minute period)
- Doors: 7.8%, open/close (2 x 3.5s) every 90 seconds. For the peak calculations a duration if 0.5s is considered (1.1%)
- Man Machine Interface: 75%, the one installed in the opposite cab is in stand-by mode.
- Horn and bell: 4% (ON for 10 seconds every 2 minutes, only in the active cab)
- Relays and contactor: 20% ~ 25%, as an estimation of connected devices.

9.A.3. BATTERY SYSTEM

9.A.3.1 EMERGENCY LOADS

In case of failure of the auxiliary power supply, the battery is able to maintain the supply of basic systems for a minimum of 45 minutes.

The systems maintained during emergency operation include (at least):

- Emergency Lighting (continuous)
- Communications (continuous)
- Door Control (cycle doors open for 20 seconds every 5 minutes)
- Propulsion control (continuous)
- Braking Power and Control (continuous)
- Operator's Console Indicators and Interlocks (continuous)
- Horn and Bell (on for 10 seconds every 2 minutes)
- Track Brakes (on for 10 seconds at end of each 20 minutes period)
- Pantograph Control (raise and lower twice)
- Headlights, tail and stop lights (continuous)
- Windshield Wiper (continuous)
- Passenger Information System

After the initial 45 minutes, the emergency lights will remain operational for an additional 45 minutes

9.A.3.2 BATTERIES

The proposed vehicle is equipped with a Pb battery, located in a battery box (stainless steel box, without painting) on the roof of the streetcar.

The battery installation and enclosure design will facilitate maintenance and safe operation of the vehicle.

During any failures or malfunctions of the battery charger, low voltage systems will be powered from the battery without causing any damage to the vehicle.

During the sizing of the battery the following parameters have been considered for a more accurate calculation:

- Aging coefficient (10 years): 0.9
- Voltage: 1.47 V/cell at 68 ºF (20 ºC)
- Voltage compensation: at 3 mV/ºC element

9.A.3.3 LVPS/BATTERY CHARGER

In CAF's design, the LVPS is the Battery Charger. This has the advantage of making the design simpler and more reliable.

Characteristics of the auxiliary converter and battery charger	
Input	
Input voltage	750 Vdc
Voltage variations	525 V - 925 V (1000 Vdc during 5 minutes) According to IEC-60850
Battery charger	
Output voltage (at 20ºC)	28.4 Vdc
Rated power	5.5 kW

The streetcar is fitted with a DC/DC specific converter for the case of flat battery, in order to allow streetcar re-energization and battery charging from the overhead line voltage supply after manual rising of the pantograph.

9.A.3.4 HIGH SPEED CIRCUIT BREAKER

The primary circuit protection is achieved mainly by the use of a High Speed Circuit Breaker (HSCB) and surge arrestor protecting the equipment connected to the high voltage circuit from over-voltage and over current situations.

The (HSCB) is located next to the pantograph, reducing the length of the cabling between them to a minimum.

The HSCB fitted in the streetcar is a DC high-speed current-limiting circuit-breaker, air cooled. It has been designed to ensure a trip free, rapid opening of its main contact, on detection of a short circuit, and to quickly extinguish the arc by generating a constant over-voltage during the whole interruption process.

The circuit-breaker is made of independent mounted sub-assemblies, corresponding to the different functions.

- Fixed insulating frame made of glass-fiber reinforced insulating material
- Main circuit, consisting of a lower connection terminal, a moving contact, an upper connection terminal, a fixed contact with horn and another horn
- Over-current release
- Arc chute
- Closing device and fork
- Auxiliary contacts assembly

9.A.3.5 KNIFE SWITCH ASSEMBLY

The knife switch will be installed between the pantograph and the high speed circuit breaker (HSCB), and will set the train in different operation modes, depending on the primary energy source:

- Normal operation: The train will be powered from the catenary, and the knife switch will allow the traction and auxiliary systems to be powered from the high voltage connection.
- Workshop supply: The train will be powered from the medium voltage workshop supply. In this mode only auxiliary loads will be powered in the train and the traction equipment remains unpowered. This way maintenance/cleaning operations can be carried out without risk while some of the auxiliary loads (HVAC, sockets, lights) are on.
- Off: The train will be disconnected from any energy source, making it safe to work on the train.

9.A.4. PANTOGRAPH

The streetcar is equipped with an electrically operated pantograph, designed for a nominal working voltage of 750Vcc and the tolerances defined in standards EN 50163/IEC 60850.

The pantograph (and High Speed Circuit Breaker) is controlled by the driver by means of a pushbutton in the driver's cab.

The pantograph is raised and pressed against the overhead wire by means of the raising spring and is lowered by means of the electric lowering device. It is electrically insulated and mounted between the base frame and the lower frame of the pantograph.

The mechanism is driven by a permanent magnet DC motor over a linear actuator with ball thread and a mechanical brake.

Figure 4. *Pantograph*

In the event of a power failure, the pantograph can be raised and lowered manually. For this purpose the motor is connected to hand crank, via a flexible shaft, which can be operated from the interior of the vehicle.

The lock down latch prevents the raising of the pantograph when in the resting position.

9.A.5. SURGE ARRESTOR

A surge arrestor is fitted in the streetcar, next to the pantograph, to protect the streetcar equipment from over-voltages, including lightning strikes.

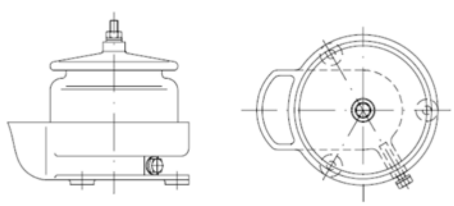

Figure 5. *Surge arrestor*

9.A.6. GROUND SYSTEM

Ground brushes will be provided for two functions, including the grounding of the equipment and the return of the traction circuit.

9.A.6.1 RETURN CIRCUIT

The currents of the power equipment return to earth through the brushes of grounding devices. Current returns of the equipment are connected along the streetcar through plates located in each car in which the connection is routed to the trucks.

9.A.6.2 GROUNDING

Similarly, the protection of ground is present along the streetcar by the connection between the grounding devices and the body of the car in the modules with trucks, and the connection of the boxes of the composition. In addition, trucks are grounded through the car body.

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SECTION 10 PROPULSION SYSTEM REQUIREMENTS

10.A. PROPULSION SYSTEM DESCRIPTION

10.A.1. VEHICLE CHARACTERISTICS

The streetcar consists of three (3) carbodies which are permanently coupled by means of articulations. The vehicle is bidirectional and has an operator's cab at each end. The end carbodies are supported by motor trucks and the central carbody is suspended.

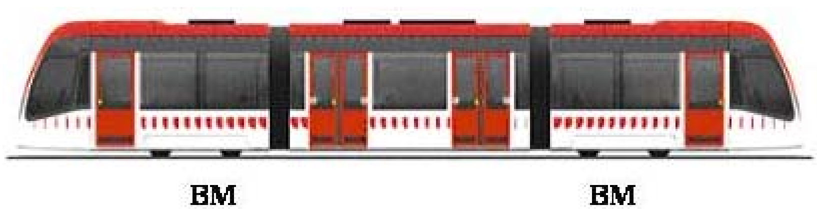


Figure 1. *Vehicle consist*

10.A.2. BASIC COMPOSITION OF ONE UNIT

Propulsion system component list
• *2 power converters, each one containing the following components :* - *2 independent inverters* - *1 auxiliary converter* - *1 battery charger*
• *2 brake resistor boxes*
• *8 Traction motors*
• *Dead battery start up system* - *DC/DC 750V DC/24V Converter*
Each power converter includes the following: • *2 main contactors and 2 pre-charge circuits* • *2 input filter capacitors* • *2 input filter inductors*

- *2 braking choppers*
- *2 inverter cores*
- *1 auxiliary converter and 1 battery charger*
- *Control electronics*
- *Cooling system*

10.A.3. POWER CIRCUIT

Each power converter is composed of two independent and interchangeable inverters. Each inverter feeds two of the four traction motors in each motor truck.

Figure 2. *Propulsion power converter box*

Because the power components of the traction converter are duplicated, a failure in one inverter only disables that inverter, the second inverter would remain operational. A diagram of the power circuit and a diagram of the electronic control unit follow.

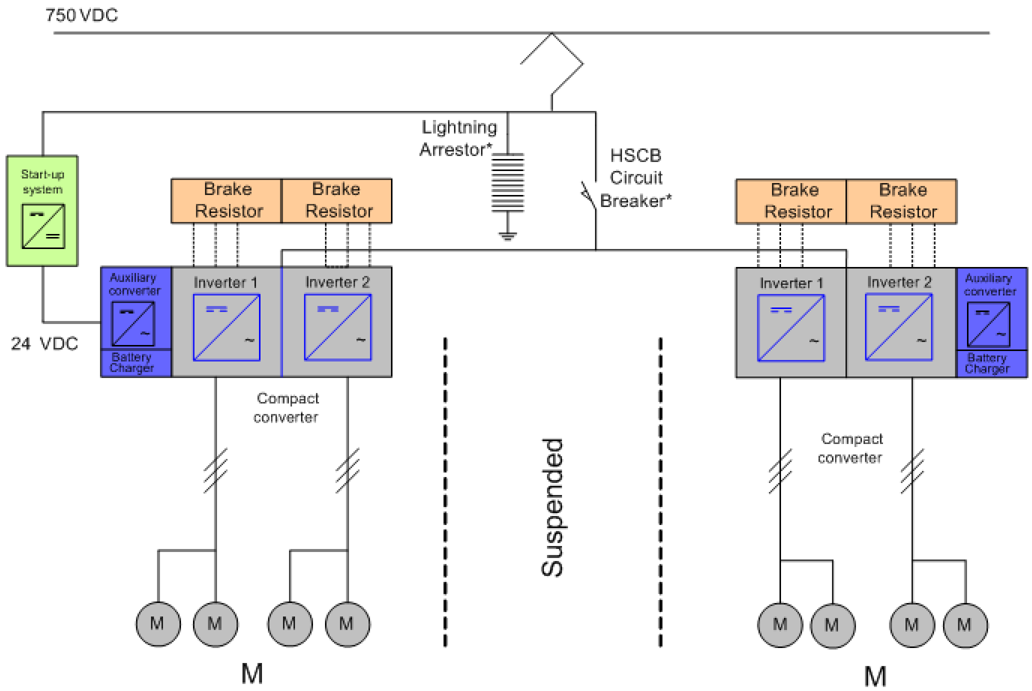


Figure 3. *Preliminary power architecture*

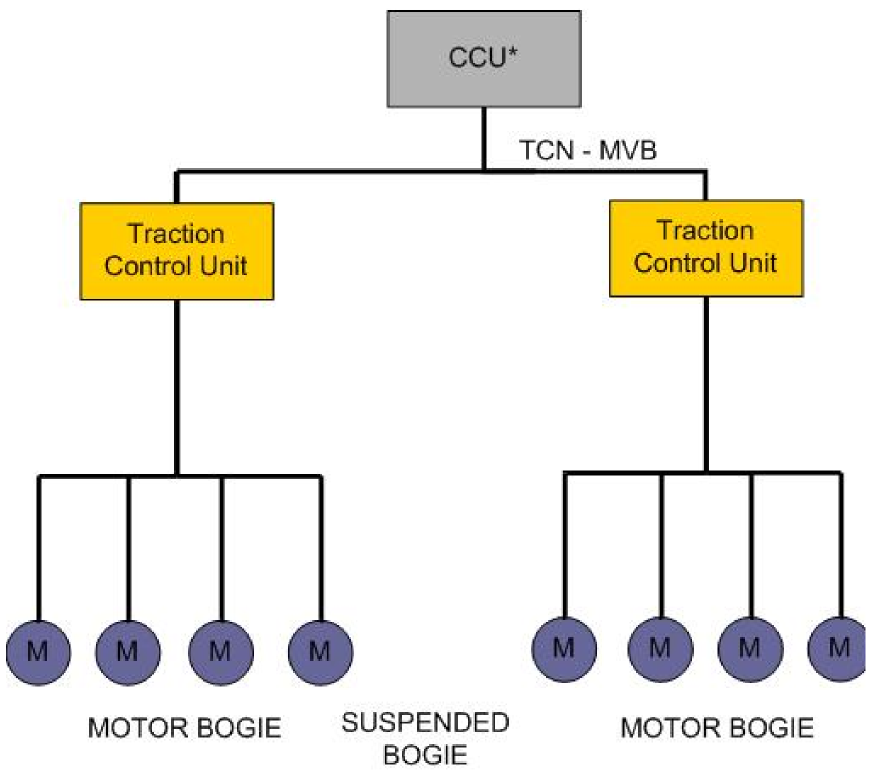


Figure 4. *Traction converter control architecture*

10.A.4. TRACTION CONVERTER

This section describes the functionality of the elements included in the traction equipment. All the components that are directly involved in the system functionality are listed and described. The traction equipment consists of various electrical sub-assemblies which are integrated into different boxes. The structure followed for this chapter coincides with the different boxes or devices to be placed on the vehicle.

Main characteristics of traction converter	
Rated power (per box)	2 x 150 KW
Maximum power	2 x 250 KW
Performance	
Three phase inverter	98%
V_{supply}	750 Vdc per EN 50163 (equiv IEC 60850) (500 – 900 Vdc)
Cooling	Forced air ventilation

Table 1. *Traction converter parameters*

10.A.5. TRACTION CONVERTER BOX

The traction converter provides the traction motors with the voltage wave shape and frequency required to achieve the performance demanded at each moment. Each converter box contains two independent traction inverters. Each inverter powers two traction motors. The inverter core consists of six IGBTs, controlled by the drivers and tripped via fiber optics, to execute the trips required to generate input voltage in the motors. The braking chopper consists of an IGBT + diode assembly. The braking resistors are installed in a separate box. Each traction inverter is equipped with a pre-charge circuit, input filter and the inverter core. Both boxes (traction and resistors) are fitted on the roof of the unit. A diagram of the traction power unit contained in one of the converter boxes is shown in the following figure.

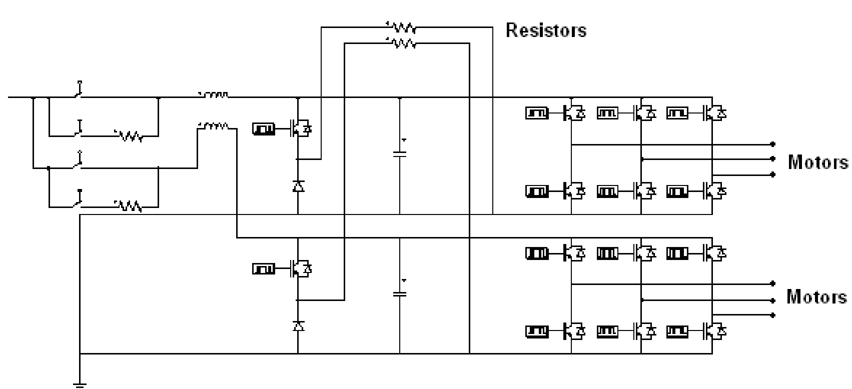


Figure 5. *Traction converter diagram*

Main characteristics of converter box	
Dimensions (incl. auxiliary converter and battery charger) with mounting brackets (W x L x H)	1901 mm x 1810 mm x 542.5 mm
Weight (incl. auxiliary converter and battery charger)	670 kg
Material	Self-supporting aluminum box
Location	On the roof

Table 2. *Main characteristics: Converter box*

The traction converter consists of the following major components:

- Line Contactor and Pre-charge Circuit

  Each traction inverter is equipped with a connection and pre-charge circuit. This consists of a line contactor, a pre-charge resistor and a pre-charge contactor. Its purpose is to limit the charge current of the capacitor of the intermediate circuit and to prevent its voltage from over-oscillating. The control unit regulates the load of the capacitor of the intermediate circuit and that of the filter capacitors. To this end the pre-charge contactor and the pre-charge resistor are used until the voltage reaches a preset value. Only after this is the line contactor closed and the pre-charge contactor opened. The contactors permit isolation of the inverter when one of these fails even when it is operating at maximum power (both in traction and in braking).

Figure 6. *Traction Equipment Line contactor and Pre-charge Circuit*

- Input Filter

  The traction equipment input filter consists of a series inductance with parallel capacitor, both of which are included within the power converter. Its function is to minimize dumping to the electrical network of harmonics produced by the traction system and to protect the system itself against network transient conditions. It also limits the input impedance.

- Current and Voltage Sensors

  The traction converter contains a series of current and voltage sensors by means of which the DC voltages and DC and AC currents are measured at various points of the traction converter. The information from these sensors and their conditioners is sent to the traction control unit to control the various processes (bus capacitor pre-charge, protections, fault detection, etc.).

- Three Phase Inverter or Inverter Core

The inverter core transforms the DC bus voltage in a three phase current with variable frequency and amplitude to power the traction motors. The losses in the traction motors as well noise generation are minimized by means of optimized modulation patterns. This is a two level inverter equipped with IGBTs. Each IGBT is controlled by its corresponding drivers which create the interface between the control signals and the power signals required to control the IGBTs via fiber optics. These drivers are fitted with the following protections:

- Short circuit: Detects short circuit to open the IGBT.
- Under voltage: Detects drop in the supply voltage for the opening of the IGBT.
- Overvoltage: Prevents the voltage between the collector-transmitter from exceeding the VCES breakdown voltage

- Braking Chopper

During braking, the brake type applied is automatically prioritized as follows:

- Regenerative electric brake
- Non-regenerative electric brake if the catenary is not receptive
- Friction brake

The braking chopper enables and controls the dissipation of kinetic power of the unit in the braking phase when the line is not receptive. It is also activated in the case of overvoltage in the intermediate circuit.

Each traction box includes two crowbar circuits, one per three phase inverter. Each crowbar circuit consists of an IGBT, a diode and an external dissipation resistor (braking resistor), where the kinetic power of the train and the over voltages generated are absorbed. Both circuits are controlled independently according to the braking requirements and/or over voltages in the corresponding bus.

- Cooling System

The converter cooling evacuates the heat produced by the losses of the IGBTs of the three phase inverter and the braking chopper, and the input filter inductance located in the same box.

The converter is cooled using forced air. The air is pulled in by a fan from the outside and flows thought a heat sink where the power IGBTs are located. The IGBT inverter and chopper are placed on the cold plate, which is responsible for distributing the dissipated power as uniformly as possible and is cooled by air flow.

Additionally, this air flow is used to cool the dual filter inductance. The cooling system design is optimized to effectively dissipate the losses of the IGBTs. This will keep the temperature of the IGBTs below a design threshold defined according to the breaking temperature semiconductors.

- Energy Recycling

  When dynamic brake is applied, the current generated is first sent to feed auxiliary systems. Once auxiliary systems have been powered, the excess energy is returned to catenary, if receptive. Otherwise, the surplus energy is burned in the braking resistors.

10.A.6. BRAKE RESISTOR BOX

The function of the brake resistors is to convert the kinetic energy generated by the traction motor into heat energy in the event that the catenary is not receptive and this energy cannot be fed back into the grid. They are also activated in the case of overvoltage in the intermediate circuit of the traction converter. The brake resistors are cooled by natural ventilation. This design minimizes external noise emissions and requires no auxiliary consumption (ventilation). It also provides high reliability due to its robustness. The electric braking prioritizes catenary regeneration. The brake resistors are only used in case of a non-receptive catenary.

Figure 7. *Brake resistor box*

10.A.7. MOTOR

The motors, four per motor truck, are suspended in the truck and the effort is transmitted via the existing couplings between the motor and gear unit. This configuration is based on having a motor at each wheel, so that each pair of motors on one side is powered by the same inverter. A complete truck is powered by a traction box with two inverters.

This dynamic design of the streetcar has been tested successfully on streetcars including those for Seville, Vélez-Málaga, Vitoria, Edinburgh, Antalya and Zaragoza, and will be installed, in the future, in Metropolitano Granada, Metro Malaga, Nantes and Besançon. The motor insulation is thermal class 200 per IEC 60349-2. The sizing of the equipment has been based on the expected maximum load performance. The motor is an asynchronous closed and sealed induction motor with squirrel cage rotor. The motor is fed into variable voltage and frequency to respond to the torque established by the traction control.

Characteristics of the traction motor	
Catenary voltage	750 V
Rated voltage	585 V
Rated current	92 A
Rated power	100 kW
Number of poles	2
Motor efficiency	> 0.92
Gear-box efficiency	0.97
Gear-box ratio	5.44
Insulation	Thermal class 220 IEC 60349-2 and IEC 60085)
Weight	315 kg
Cooling	Self-ventilated, closed motor

Figure 8. *Traction motors (x2)*

10.A.8. DEAD BATTERY START-UP SYSTEM

The streetcar will be able to start-up the electrical system when the battery is completely discharged and there is no power in the 24 Vdc line. To this end, the streetcar will be equipped with a High Voltage/Battery Voltage passive DC/DC converter that will feed all the needed electronics to start-up the unit only with the catenary power source.

This way, in the case the batteries are discharged, the pantograph may be manually raised. The DC/DC converter will power the High Speed Circuit Breaker (HSCB) and the Converter so that the battery charger starts working. At this point the battery charger will power the whole vehicle and will charge the battery.

The DC/DC converter will be located in a separate box and will include diodes in order to provide power only when the battery is discharged and the pantograph is connected to the line.

Characteristics of the Dead Battery Start-up System	
Maximum Power	850 W (2 minutes)
Dimensions	11.8" x 11.8" x 14.2" (300 x 300 x 362 mm)

Table 3. *Dead battery start-up system*

10.A.9. CONTROL ELECTRONICS

10.A.9.1 DESCRIPTION AND ARCHITECTURE

The architecture of the Traction Equipment Control Unit is based on the VEGA Control Platform (Vehicle Electronics for Generic Applications). This platform has been developed to support the electronic functionality of different railway applications. One of the reference applications of the VEGA Platform is traction control, including set point functionality such as traction torque, electrical brake, driving modes, sensor reading, contactor control, circuit breakers, IGBTs, inverter mode modulation, rectifier mode modulation, etc. A Control Platform is a system that enables a compatible application to execute a number of standard functions. The following is a very simplified overview of the basic functionality of a control platform. The following picture depicts the interfaces used for accomplishment of this functionality.

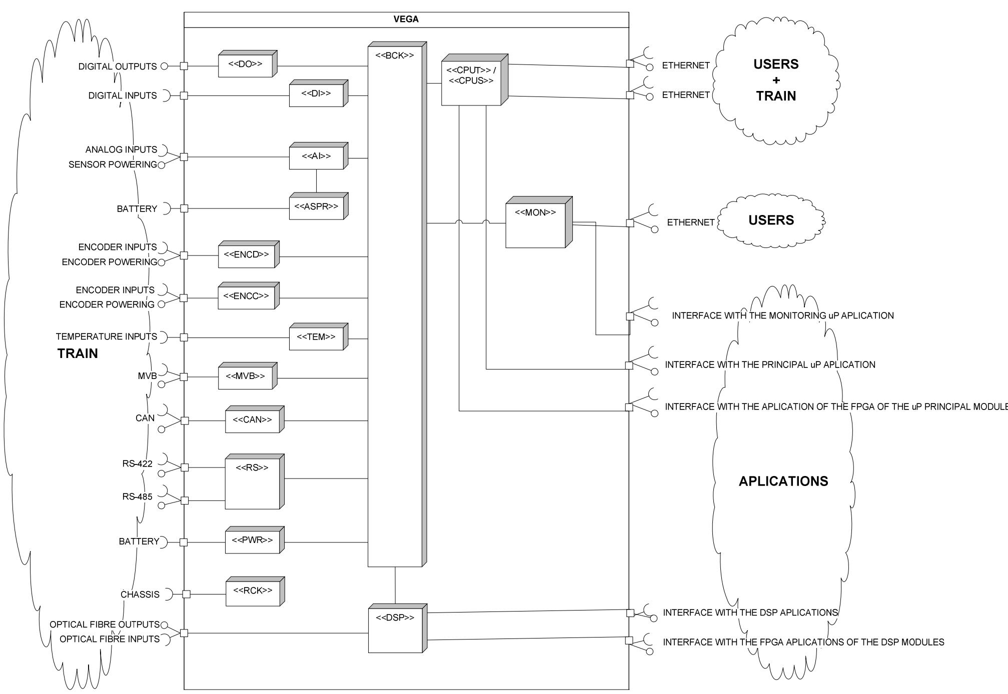


Figure 9. *VEGA interface equipment*

- Reading of railway battery voltage level digital inputs.
- Writing of railway battery voltage level digital outputs.
- Reading of analog inputs.
- Specific reading interface for certain sensors and peripherals used in the railway environment, such as encoders, temperature sensors, IGBT drivers, etc.
- Management of communications according to several railway or non-railway standards.
- Information processing capacity in specific processors for the application.
- Information storage capacity either volatile or otherwise.
- Capacity to supply power to certain peripherals

10.A.9.2 SUBSYSTEMS AND FUNCTIONS

The VEGA system is configurable and scalable and is housed on a rack where a backplane connects various modules or boards with different functionality. The most significant subsystems and their general functionality are described below.

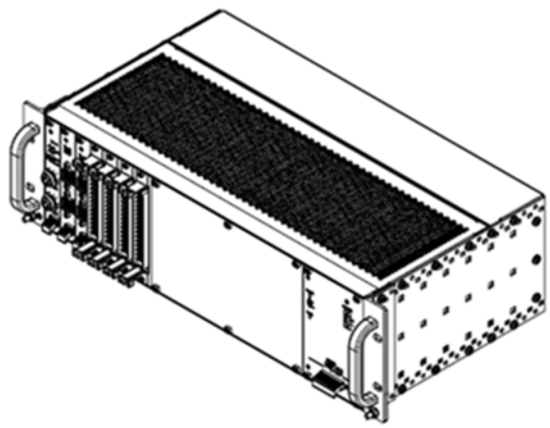


Figure 10. *VEGA rack example*

- sCPU: This is the main processing unit of the system for traction applications. It executes the main uP application. It also manages all communications between all subsystems, including the various communication buses of the backplane.
- sDSP: Processing Unit for signal management. It executes the DSP application and the FPGA application of the DSP module. These are particularly suitable for signal digital processing, floating point operations and sequential logic operations for signal modulation. It also controls the optic interface of the VEGA system.
- sMON: Processing Unit for monitoring. It executes the monitoring uP application. It also provides an Ethernet based electric interface with the user.
- sBCK: Backplane. It provides communication for all subsystems except for the ASPR. There are several BCK variants, of varying size to adjust to different configurations:

- sAI: Reading of the system analogue inputs. It reads analogue inputs. It also distributes voltage supply to analogue sensors.
- sENC: Encoder reading. It reads the speed and counts the pulses of the system encoders. It also generates and distributes voltage supply to these encoders.
- sDI: Digital input reading. It reads the system digital inputs.
- sDO: Writing of digital outputs. It writes and monitors the system digital outputs.
- sTEM: Temperature input reading. It reads and monitors the system temperature inputs. This consists of thermal-resistance sensor reading.
- sMVB: MVB communication. It offers MVB communications line.
- sCAN: CAN communication. It offers two CAN communications line.
- sRS: RS-422 and RS-485 communication. It offers one RS-422 communication line and one RS-485 communication line.
- sPWR: Power supply. It generates the voltage supply for all subsystems and encoder sensors from the battery voltage. There are two PWR variants, of varying power, to adjust to different configurations:
- sASPR: Analogue sensor power supply. It generates the voltage supply for analogue sensors from the battery voltage.
- sRCK: System Rack. This is the system mechanical structure and shell. It offers an appropriate connection to the train underframe. There are several RCK variants, of varying size to adjust to different configurations.

10.A.10. SOFTWARE DESCRIPTION

10.A.10.1 TRAIN SOFTWARE

The train software is executed in the high level traction control unit and shall principally provide communication with the control and monitoring equipment via TCN-MVB and implement the specific traction control functions for the traction unit, sending the necessary torque settings to the low level control unit and supervising its operation.

The high level traction unit also calculates the friction brake settings of the motor trucks and provides coordination between the electric brake and friction brake (blending), i.e. carries out the BCU function. The wheel anti-slide protection of the motor trucks will also be provided as a function of the high level traction control unit.

With the VEGA platform the train software is distributed on the boards making up the VEGA system. The CPU main software is executed on the CPU board and will primarily provide for the communication with the control equipment via TCN-MVB, as well as providing the interfacing function between the train and the control logic system (implemented on the CPU board as well) by generating high level torque values which are transmitted to the DSP board via backplane. The purpose of the control strategy (or control software), executed on the DSP board, is to control traction motors, with a mere 20 micro-

second work cycle, in which the torque high level value is turned into low level signals, creating the most suitable traction control for traction motors. Finally, the monitoring process is executed on the MON board releasing the CPU board of this task.

- Communication with the Train: Allows connection to the train control and monitoring equipment (MON board) via the TCN-MVB bus. This is a class 2 node permitting sporadic messaging. Communication with the control and monitoring equipment must be in accordance with the interface specification document that shall be established in the initial phase of the project.
- Cooling Control: This controls the fans of the converter box and other items making up the cooling system of the motors, filters, brake resistors, etc.
- Log and Alarm Record: This function records the alarms that trip on a non-volatile memory device, saving a log of events whereby the problem can be analyzed. The alarms can be notified, as appropriate, in real time via TCN-MVB bus to the control and monitoring equipment. It is equipped with a remote download mechanism for log and alarm records via local connection (RS-232) or ETHERNET.
- Limitations: Some limitations are performed due to maneuver mode, reversing, parking and other to be agreed at project phase.
- Self-Diagnosis: This function implements fault self-detection logic which is executed periodically, either as a result of a specific event (startup of control equipment, connection of electronic equipment, etc.), or at the discretion of maintenance staff.

10.A.10.2 CONTROL SOFTWARE

The control software is executed in the inverter control unit and basically provides low level control of the power electronics (inverter, braking chopper, etc.). It implements the control strategy receiving periodic settings of the high level traction control unit via a CAN bus.

- Inverter control: Implements the control strategies required to control the motors, optimizing consumption and operation cycles of the power unit. It implements the appropriate algorithms to meet the requirements laid down, regarding speed, consumption and comfort. It is capable of implementing the most appropriate control modes depending on the speed.
- Braking Chopper Control: Controls the braking chopper to implement various functions, such as the control of the bus voltage in electric braking, protection against sudden voltage surges, etc.
- Anti-Slip/Slide System: This system implements slip detection and correction during traction and a wheel slide correction during braking. The wheel slide protection system detects and avoids the slide during electric braking. During application of blended braking, wheel slide shall be coordinated by the traction equipment.
- Limitations: Various limits are implemented, such as torque slopes limit, limits according to the characteristic curves of traction/braking, limits according to maximum speed, limits according to temperatures, etc.

- Protections: Various protections are implemented, such as overcurrent, overvoltage, excessive temperatures, peripheral equipment data reading errors, loss of communications and execution logic errors. Depending on the situation, there may be a reduction of performance, the traction may be disabled or the equipment may be started.
- Self-Diagnosis: This system performs operation checks on some components during start up. If a serious error is detected during this process, the startup is aborted immediately to prevent damage to the equipment.

10.A.10.3 INTERFACE BETWEEN THE PROPULSION AND BRAKING SYSTEM REGARDING THE SPIN/SLIDE CORRECTION

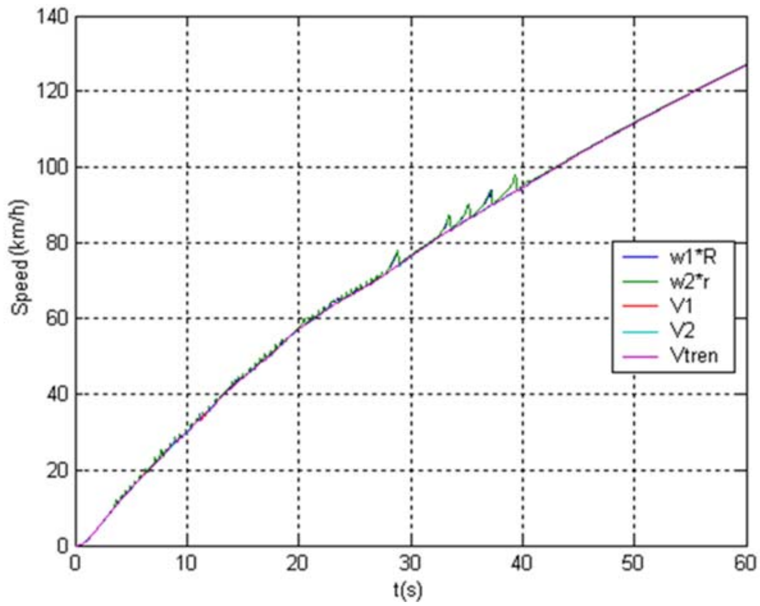
The Anti-Slip/Slide Control (ASSC), programmed onto CAF Power & Automation traction equipment, provides all of the logic and algorithms designed to adapt the effort given by motors to the maximum effort possible with the friction condition on wheel-rail contact in each moment and to the effort required by train control. The ASSC is designed to reach the maximum effort when friction effort on wheel contact is reduced because of external reasons, maintaining wheels' sliding under a reasonable limit to ensure minimum damage to the wheels. The main objectives of the ASSC are:

- Guarantee that the maximum available traction/braking effort is made at every moment.
- Sliding/slipping control: Reduce eventual high sliding peaks and avoid long periods with sliding on wheels to prevent excessive wheel wear.
- Structure vibrations: Reduce torque variations as much as possible due to ASSC to avoid vibration on mechanical devices and maintain passenger comfort.
- Control stability in different operating conditions: Defects on rail, curves, etc.

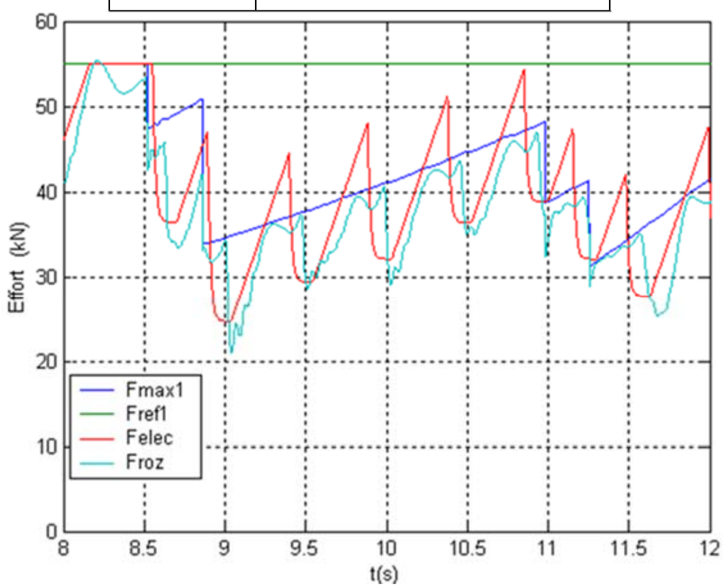
The method used for ASSC is the estimation of maximum usable friction effort, considering motor-axle and friction effort dynamic equations. The ASSC has 3 main stages:

- Slipping/sliding state detection on each axle
- Effort reduction to adapt it to maximum friction effort usable in each moment
- Effort recovery when good friction condition is reached on wheel-rail contact.

Before describing each stage, some illustrations are included to show control behavior.



W1*R	Axle 1 tangential speed
W2*R	Axle 2 tangential speed
Vtren	Train's speed



Fmax1	Maximum possible effort with no sliding
Fref1	Train reference effort
Felec	Motor effort
Froz	Real maximum possible effort considering sliding

Figure 11. *Graphs showing ASSC Control Behavior*

10.A.10.4 SLIPPING/SLIDING DETECTION

Slipping/sliding detection is made according to two parameters:

- Axle's tangential acceleration: If an axle's tangential acceleration is higher than the maximum expected acceleration in normal operation, this axle has a higher acceleration than the train has. The axle's angular acceleration is not null and this axle is slipping.
- Speed gap between one axle and train: If an axle tangential speed is different from the train's speed, this axle is working with some sliding. If this gap is higher than that equivalent to the maximum acceptable sliding, this axle is considered to be slipping/sliding and the control is activated.

10.A.10.5 CONTROL ACTUATION: EFFORT REDUCTION

When a sliding/slipping state has been detected, traction effort on the axis which is sliding/slipping is reduced until it reaches the value relevant to maximum friction effort usable in the forward direction. This value is calculated continuously by the control processor as the equivalent torque applied on the axis for which angular acceleration is null. This way, when angular acceleration is zero, there is only tangential acceleration and sliding/slipping is avoided.

10.A.10.6 EFFORT RECOVERY

After reducing the effort, if no sliding/slipping is detected on the axle the effort is increased to a reference value according to an increasing ramp. If the sliding/slipping state is again detected during effort recovery, another decreasing cycle is commanded and these cycles continue until proper grip is reached on wheels and slipping/sliding is stopped.

10.A.11. OVERLOAD AND TRANSIENTS PROTECTION

The elements that are protected against overloads are the traction motor, the IGBTs, the brake resistor and the line filter inductance. The over-temperature protection system performs the same way for all of them. The protection system has a security temperature range, a warning limit and an error limit to conform a gradual operation of the system:

- The warning limit fixes the threshold at which there will be a gradual reduction of system performance to reduce the rise in temperature.
- The error limit fixes the threshold beyond which the inverter will perform a controlled stop

Temperature in the different elements is obtained as described as follows:

- Motor temperature estimation is based on the motor thermal model. Based on the motor losses it's possible to estimate motor's temperature. In addition to this thermal model, an additional temperature estimation system based on the motor's stator resistance measurement is used. From this measurement the average stator temperature is directly calculated.
- The temperature in the inverter IGBTs is measured using Pt100s that are installed on the cold plate.

- The temperature in the brake resistor is directly obtained from its resistance value. This resistance value is calculated using the bus voltage and the brake resistor current measurements.
- The temperature in the line filter inductance is obtained from its thermal model. Using the line current, the inductance's average temperature value is obtained.

Protection against transients is made in a different way depending on the consequences that each incident implies. The protection system uses the following measured magnitudes to perform different protection functions:

- Voltages: Line voltage and bus voltage
- Currents: Inverter input and return currents and motor phase currents
- Motor speed.

All incidents that can be detected have an associated severity-level that determines the actions to be carried out by the control. There are seven severity levels, which in order of decreasing severity, are classified as:

- Level 0: Opens all contactors (circuit breaker, main contactor and pre-charge contactor)
- Level 1: Opens the main contactor and the pre-charge contactor.
- Level 2: De-torquing and de-fluxing of motor, triggering a fast controlled stop. Then, the main and pre-charge contactors are opened.
- Level 3: Opens all IGBTs.
- Level 4: Torque and flux override and opening of IGBTs.
- Level 5: Reduces system performance, depending on the nature of the incident.
- Level 6: Light incident, report only.

With this protection system, the propulsion system protects itself from overloads and transients.

10.A.12. PROPULSION SYSTEM INSTALLATION DRAWINGS

The propulsion system will be installed in the cab cars, as shown in the figure below:

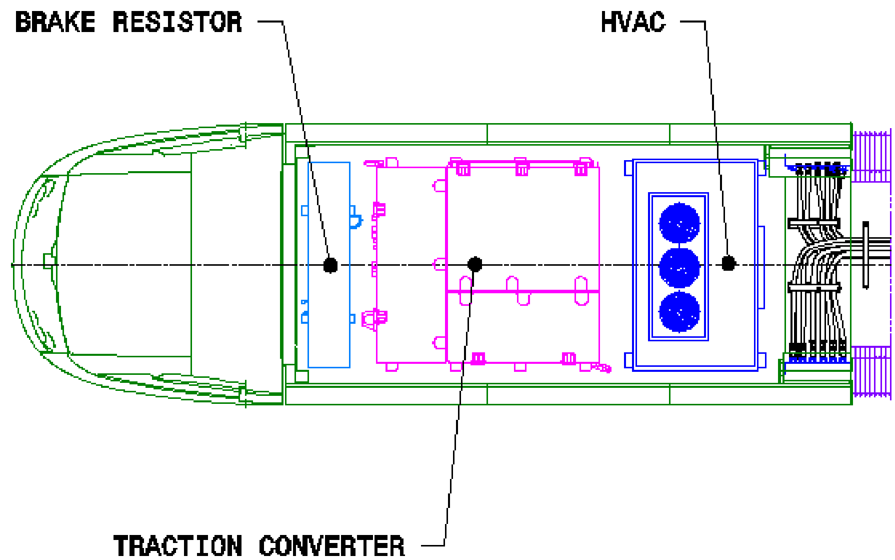


Figure 12. *Propulsion system installation in the C1 car*

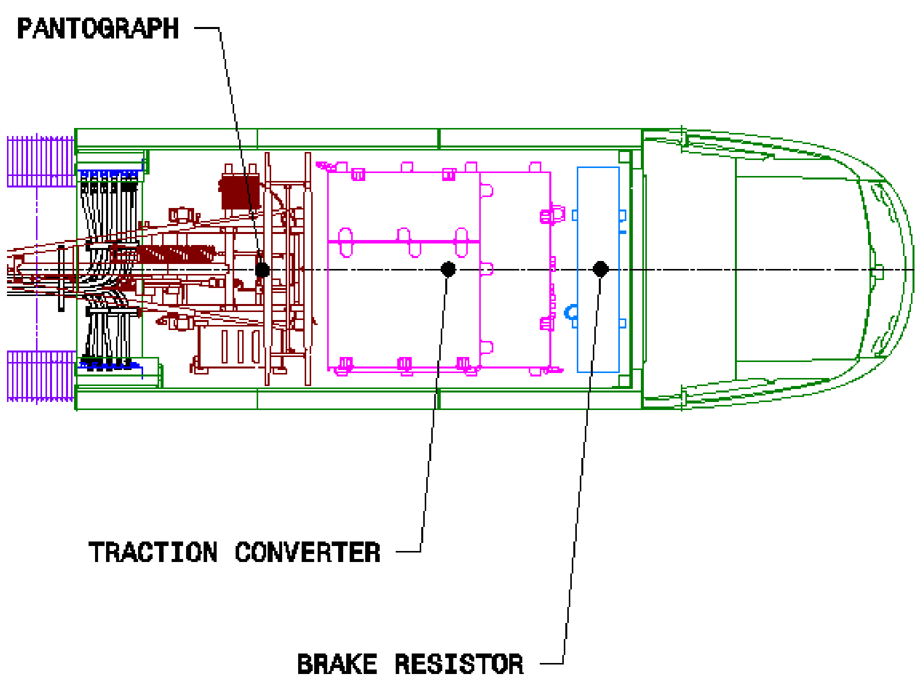


Figure 13. *Propulsion system installation in the C2 car*

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Sub-Part A – VEHICLE DESCRIPTION

SECTION 11 TRUCK ASSEMBLIES REQUIREMENTS

11.A. GENERAL

The streetcar will be supported by URBOS 100 type trucks manufactured by CAF. This truck type is service proven on many CAF projects, such as current fleets in Cincinnati, Kansas City, Seville, Zaragoza, Birmingham, Edinburgh, Luxembourg, Sydney, Budapest, Besançon, and Debrecen. This type of trucks is currently being manufactured and delivered for the cities of Amsterdam, Utrecht, Newcastle, Canberra, etc.

The truck is “fixed” type meaning there is hardly any rotation between truck and carbody. Trucks are based on the Independently Rotating Wheels (IRW) concept and axlebridges instead of wheelsets are utilized. The wheelbase is 1800 mm. This truck design provides proper wheel load equalization and good curving behavior especially in curves with sharp radius, resulting in reduced wheel and rail wear. Trucks of the same type manufactured under this contract will be interchangeable.

All truck mounted equipment is fitted in the sides of the frame so that the central area is clear to allow the widest aisle possible through the truck. This arrangement provides good access to truck mounted equipment. The suspension components are mounted by means of maintenance free resilient mounts.

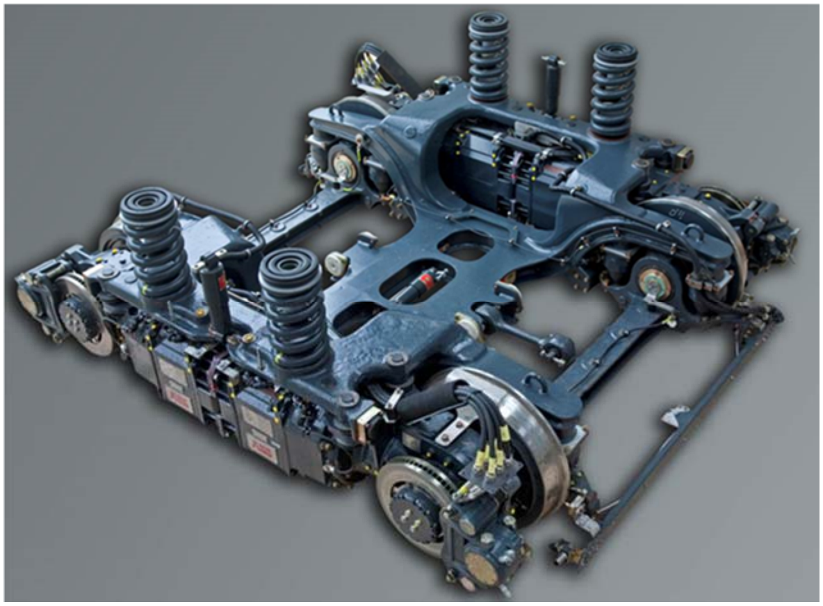

Figure 1. *URBOS 100 motor truck, 1435 mm gauge*

The trucks clear the top-of-rail plane by 50 mm in worst case conditions, including fully worn wheel and failed primary and secondary suspensions.

11.B. SUSPENSION SYSTEM

The suspension system keeps the vehicle within the dynamic clearance envelope while minimizing the wheel unloading. In addition to the resilient wheels, the trucks will have two main suspension stages to achieve good comfort levels.

11.B.1. PRIMARY SUSPENSION

The primary suspension connects the truck frame to the axlebridge and transmits both the vertical and transversal forces between them. The suspension will be based on rubber-steel springs which are also responsible for axlebridge guidance. This rubber suspension has its own damping capability, which makes it unnecessary to use external dampers. The vertical stiffness of the springs will be studied so it can deal adequately with vertical irregularities in the track, ensuring as uniform as possible load distribution between the truck wheels, therefore obtaining optimal adhesion. The stiffness on the horizontal plane is responsible for axle guidance.

There will be two (2) springs per wheel. The springs will be grouped per wheelset in groups of four attending to their stiffness so that they match each other. Primary suspension spring creep is compensated by means of shim packing under the springs when required.

There will be bump and lift stops to limit primary suspension stroke. The bumpstop has rubber in order to avoid direct metal-to-metal contact. To limit the extension, there will be a liftstop that limits suspension travel and allows the truck to be raised with the axlebridges hanging.

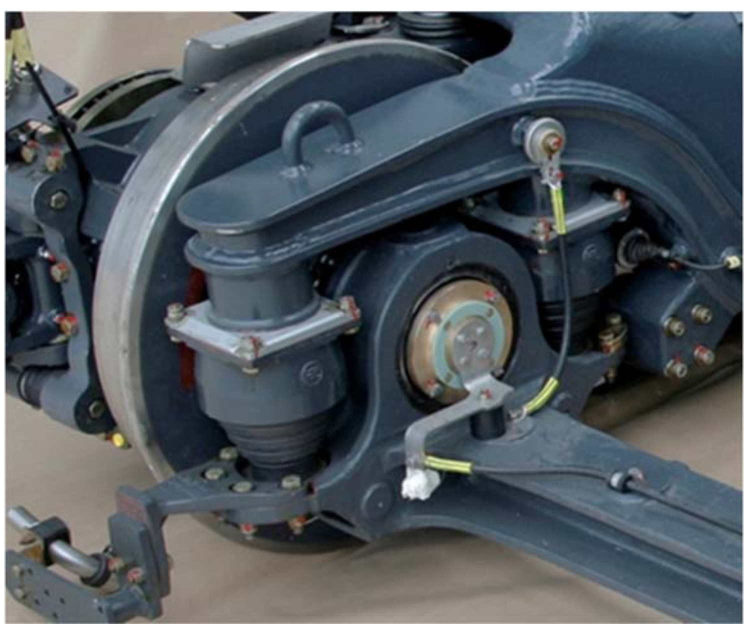

Figure 2. *Primary suspension*

11.B.2. SECONDARY SUSPENSION

The carbody will be supported by the coil springs of the secondary suspension. There will be four (4) coil springs per truck fitted between carbody and truck frame with intermediate resilient items.

The rubber bumpstops inside the coil spring system will come into operation when the maximum load situation is reached, making the suspension progressive and limiting the maximum stroke

Figure 3. *Secondary suspension*

Traction and braking efforts will be transmitted via one drag link. All suspension elements will be fitted with rubber mounts and articulations so that vibration transmission is minimized. These rubber mounts are maintenance-free.

The secondary suspension will also have a system of wheel wear compensation to keep the height of the floor constant. This consists of shim packing under the coil springs. The installation of wheel wear compensation shims will be easy; it will not be necessary to remove the truck from the carbody to fit them, as the operation is made via a pneumatic facility within the bogie.

There will be transversal resilient stops with progressive stiffness to absorb the dynamic impact produced in this direction, to limit the displacement and to avoid direct metal-to-metal contact.

The trucks are equipped with two vertical hydraulic dampers and a transversal hydraulic damper. The dampers are fitted with maintenance free rubber joints.

11.C. TRUCK FRAME

The truck frame is the main part of the truck, onto which many components are mounted. The truck frame has a box section geometry made up of electric arc welded sheet.

The sheet material is S355NL in accordance with EN10025-3. The mountings that are welded to the truck are casted and the material is G20Mn5 in accordance with EN 10293. Both materials are commonly used by CAF.

All the parts are prepared to allow optimal weld penetration. The welding is carried out by means of a MAG type semi-automatic welding procedure.

Once the frame has been assembled and welded, it undergoes an annealing process to relieve residual stresses resulting from welding.

The geometry has been designed to obtain a rational distribution of forces, preventing stress concentrations between parts and avoiding abrupt changes in cross section. The truck frame was designed in accordance with EN 13749. Permitted stress levels were considered, as well as fatigue limits in accordance with that stipulated in Rapport ORE Question B12/RP 60 for this type of material. The elastic limit of the material was established as the as the operating limit considered for operation under exceptional loads.

11.D. TRACTION EQUIPMENT

11.D.1. TRACTION MOTOR

Each truck has four motors which are assembled together two by two. Their shafts are longitudinally arranged with respect to the track axis. Each motor is joined to the gear unit case to form a single assembly. This gear-motor assembly is completely frame hung with a number of resilient rubber mounts, so as low as possible unsprung mass is achieved. The assembly can be dismounted from the side of the vehicle without the need to previously dismount the truck.

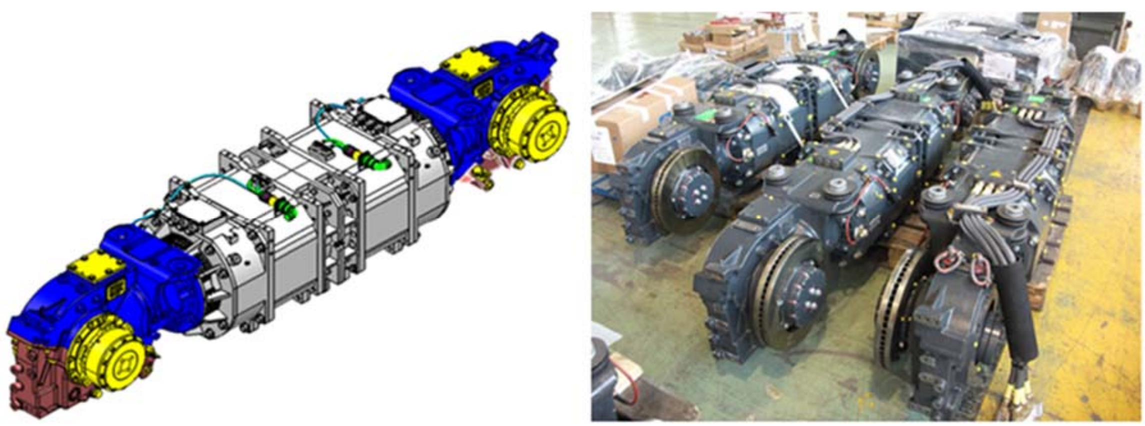

Figure 4. *Motor Gearbox assembly*

Each motor drives a gear unit which transmits traction torque to the wheel axle via a toothed coupling, and allows movement caused by the strokes of the primary suspension. A resilient star type coupling is mounted between the motor and the gear unit. The four motors/wheels are able to rotate independently from each other. This results in lower noise production and reduced wear of wheels and rail.

11.D.2. GEARBOX

The gear unit is dimensioned in such a way as to transmit the maximum efforts in both propulsion and braking, as well as those efforts arising from the vibrations caused by the rolling of the axles.

The gearbox housing is manufactured by casting and is suitably machined to allow for interior assembly of the gears and bearings. Gears are hypoid type. This type of gear unit offers silent operation.

Lubrication is by means of oil splashing for the gear wheel and by gravity for the pinion and bearings. Protection against oil leaks or dirt ingress is provided by a system of labyrinths with non-moving parts which could become subject to wear. The gearbox is fitted with an inspection lid for checking the gear condition, as well as with the corresponding drain and fill plugs and level indicator. One plug is equipped with a magnetic separation system for metallic particles.

11.E. FRICTION BRAKE EQUIPMENT

The truck mounted friction brake equipment has the following parts:

- Disc rotors.
- Brake calipers with corresponding brake pads.
- Electromagnetic track brakes.

The brake operation is electro-hydraulic with an accumulator spring. In motor bogies the brake calipers are fixed to the gearbox housings. The calipers are of inverse type, so that in the event of hydraulic pressure loss, the brake pads are pressed against the discs offering maximum braking. Therefore, the system operates with built-in safety.

The brake calipers are equipped with an automatic gap adjustment system between pads and disc so that the gap remains constant, regardless of the wear accumulated in both.

In addition, two electromagnetic track brakes are incorporated, one at each side. They provide additional braking power in the event of an emergency. The electromagnetic track brakes are hung from axlebridges. Suspension is by means of coil springs with a mechanism to regulate the gap to the rails.

11.F. AXLE BRIDGE

The axlebox bridges are free-wheel type and consist of a casted double “T” beam with press-fitted cylindrical journals at its ends. The axlebridges are interchangeable with other axlebridges of the same type. The design of the axlebridge allows the use of underfloor wheel lathes with removal of neither the trucks nor the wheels.

The wheels are mounted on the journals by means of tapered roller bearings. Bearings are assembled between the axle box bridge and the wheel hub. The assembly is projected to prevent any ingress of dirt and to prevent grease from escaping. Its L10 life rating is over 1.6 M km under AW3 loading.

Figure 5. *Axlebridge with independent rolling wheels*

The current return devices and the speed sensors are mounted on the axle-box bridges. The shunting resistance of the axlebridge is lower than 0.01 Ω from tire tread to the tire tread on the opposite side.

11.F.1. WHEELS

Wheels are resilient type. It consists mainly of the hub, the tire, a closing ring and a number of resilient blocks between the tire and the hub. The conception of the wheel is based on an approved design. It is already service proven in Cincinnati, Kansas, Houston, Birmingham, Seville, Zaragoza, and other projects, and will also be used in Boston LRVs and Utrecht tram among others. The wheel includes shunts to connect electrically the wheel tire and the hub.

New and worn wheel diameters are 590/510 mm. The optimum wheel profile will be selected during Design Stage based on the Wheel Rail Interface Study.

11.G. WHEEL LUBRICATION SYSTEM

The leading axle of each end bogie incorporates a flange-lubrication system to reduce wheel wear, which is compliant with EN 15427:2008. Its operation is interlocked with the position of the reversing system, in such a way that only the system on the leading axle will operate whichever way the car is moving. There are two lubrication nozzles per wheel, one for the flange root and another for the flange back ensuring a proper lubrication.

11.H. OTHER EQUIPMENT

The motor trucks are fitted with sanding equipment to increase the wheel to rail friction coefficient.

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SECTION 12 FRICTION BRAKING REQUIREMENTS

12.A. FRICTION BRAKING SYSTEM DESCRIPTION

12.A.1. DESIGN

During regular service, the Electro-Dynamic brake performs most of the vehicle braking. However, the friction braking system provides full braking in case of dynamic brake failure. The friction braking system consists of disc brakes with calipers and magnetic track brakes.

12.A.2. OPERATION AND BRAKE BLENDING

Electronic microprocessor controls for the system are provided by a Knorr ESRA-based electronic control unit (ECU) for complete vehicle leveling control, and a Hydraulic Control Module (HCM) for brake pressure control on each truck.

The Traction Control Unit (TCU) of the streetcar manages the friction brakes and substitutes the Electro-Dynamic (ED) brake with the friction brake on each motor. The ED brake has the highest priority in service braking.

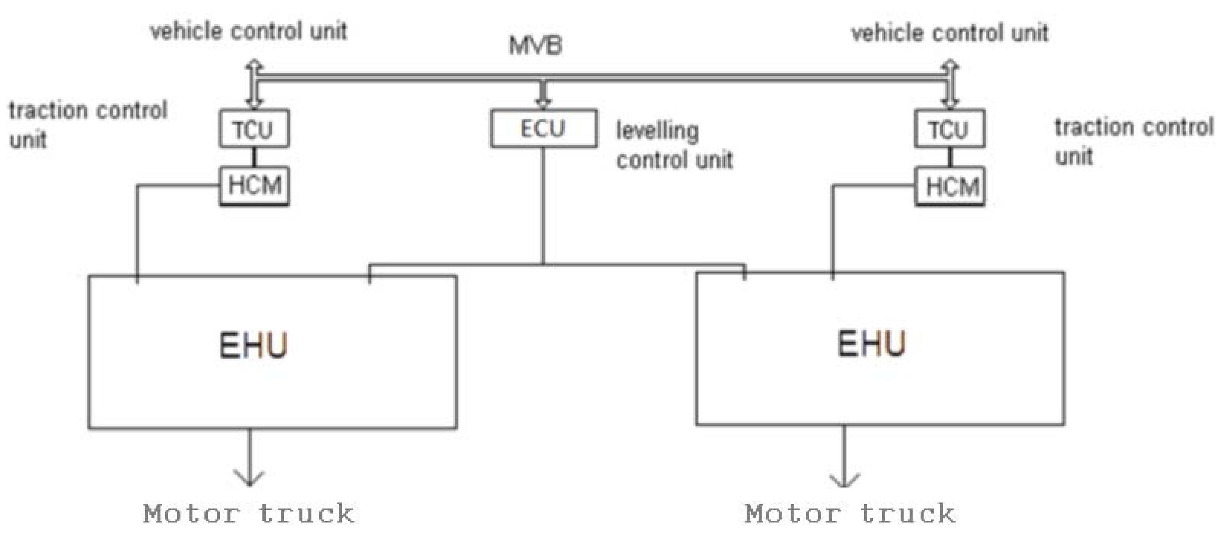


Figure 1. *Diagram block: Brake Control*

Wheel slide Protection (WSP) and jerk control functions are provided on all trucks; their operation is managed by the TCU on each motor truck. The friction brake system operates with an inverse type actuation. When there is no pressure, the spring applied actuator defaults to a full brake application. Each wheel on the vehicle consists of an actuator to initiate friction braking. The level of brakes will be:

- Service Brake: This type of braking is carried out by the Electro-Dynamic (ED) brake alone until speed is down to 4 mph (7 km/h). Under this limit and until stop, mechanical friction braking is applied. Friction braking is necessary at high speed to compensate for the reduced efficiency of the ED brake between maximum speeds, generally above 34 mph (55 km/h). The combination of ED brake and friction brake is driven by each TCU on each motor truck. The average deceleration is 3.00 mph/s (1.34 m/s^2) from AW0 to AW3.
- Maximum Brake: Maximum brake is performed by blending ED brake, magnetic track brake, and friction brake. It is the strongest braking possible. Maximum braking is activated when the operator pulls the Master Controller beyond the full service brake position. The deceleration rate will be at least 5.0 mph/s (2.25 m/s2) from AW0 to AW3.
- Emergency Brake: Emergency braking is a combination of friction disc brakes, magnetic track brakes, ED brake, and the application of sand. Emergency braking is activated by the operator's depression of the emergency push button switch. For brake entry speeds between 15 mph (25 km/h) and 42 mph (70 km/h), the average deceleration is 5.0 mph/s (2.25 m/s2) from AW0 to AW3.

12.A.2.1 PARKING BRAKE AND BRAKE RELEASE

- Parking Brake: A parking brake valve completely removes all the pressure from the caliper once the valve is de-energized such as when the car is keyed off. This allows the maximum spring force to be applied for "parking brake". The force provided allows the retention of an AW4 loaded vehicle on a slope of 10 percent.
- Brake Release/Cutout: In the event of a failure or a loss of power to the brake control system, the spring-applied brakes can become applied. The brake system includes the provision for electrical/mechanical brake release/cutout.
  - Electrical Release/Brake Cutout: The system includes the provision for the electrical release/cutout of a truck by the use of an auxiliary release valve. The energized valve releases stored accumulator pressure to release all calipers on the truck. This valve operation is manually controlled from the vehicle. Operation of the release valve prevents any brake command reaching the caliper, thereby providing an electrical cutout facility.
  - Mechanical Release/Brake Cutout: The friction brakes can be mechanically released in case there is no power to operate the auxiliary release valve or if the system is not pressurized.

    The calipers are mechanically released by means of a small tool to which torque is applied. After mechanical release, the caliper braking forces are automatically reactivated by several hydraulic brake "release and apply" applications.

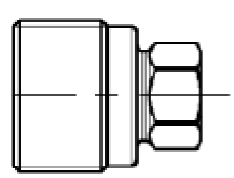


Figure 2. *Mechanical release tool*

12.A.3. BASIC SYSTEM CONFIGURATION

12.A.3.1 ELECTRONIC CONTROL UNIT (ECU)

The ECU is based upon Knorr's ESRA (Electronic System for Railway Applications) KBGM2-H. The ECU is a standardized microprocessor controlled hardware and software platform, designed to interface with trainlines and other interface signals from the vehicle. The leveling electronics system includes diagnostic capability and fault annunciation features, which interface with the vehicle systems. Communication is provided to the vehicle by utilization of E-Com cards that provide an interface between the ESRA CAN bus and the carbody Ethernet and MVB communication networks.

12.A.3.2 ELECTRO HYDRAULIC UNIT (EHU)

One EHU controls each truck. The EHU is self-contained and includes the pump, motor, reservoir, and all control valves and equipment necessary for service, emergency, and park braking. The hydraulic diagram of one truck is shown in Figure 3. Hydraulic pressure accumulators are separate from the EHUs. This unit controls a single pressure output to modulate the caliper brake pad force for both power truck axle friction brakes. As the caliper is a "passive" spring applied type, hydraulic pressure is increased to act against the spring force to reduce braking effort. Conversely, reduction in hydraulic pressure results in an increase in brake force up to the maximum available from the spring element.

12.A.3.3 HYDRAULIC CONTROL MODULE (HCM)

The HCM board transforms the brake force demand signal from the Propulsion Control Unit into proportionate signals to control the valves and drive the pump motor of the EHU. The hydraulic pressure can be input and regulated by pressure sensors.

12.A.3.4 DIAGNOSTIC

The HCM provides diagnostics for troubleshooting purposes. HCM can annunciate internal faults such as I/O shorts, open circuits, sensors out of range, or internal processing errors. The reaction to the faults may be configured to allow for specific fault relay responses, fault LED indication responses, apply or release indication responses or power output responses.

12.A.3.5 BRAKE CALIPERS

The calipers, Model HC1P28, are lever-type-spring applied calipers. These units utilize a single force cartridge, Model P28, and include an automatic slack adjuster and piston retraction mechanism which requires no preventative maintenance. The force cartridges compensate fully for pad and disc wear, yet retract the piston slightly (1-2 mm) to prevent glazing of the pads. The caliper incorporates a hydraulic release circuit which allows the release of the brakes when there is no power on the car. The manual release of the caliper is accomplished through the use of the auxiliary release unit.

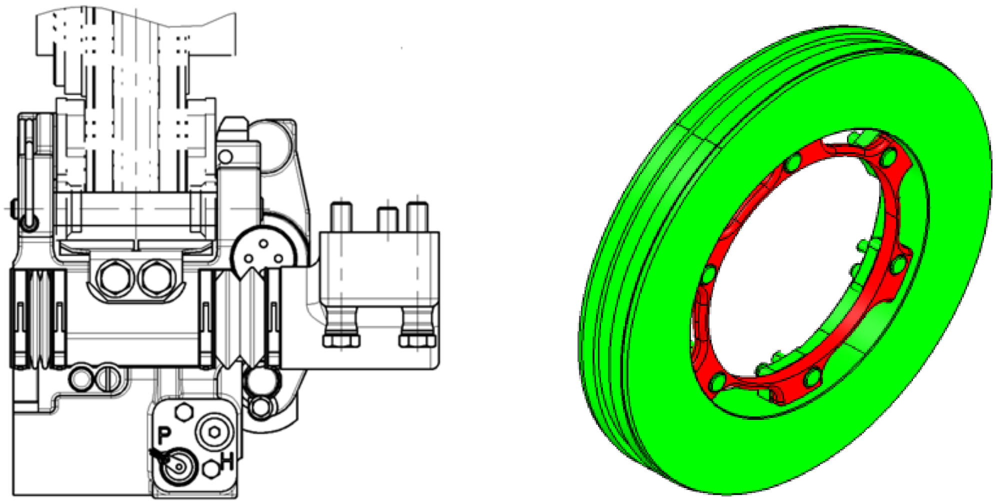


Figure 3. Brake caliper and brake disc

12.A.3.6 BRAKE DISCS

The brake disc specified for the Power truck is 400 mm outside diameter by 60 mm wide, and has a large internal bore for shrink fitting to a hollow drive tube. The friction rings utilize Knorr´s patented “pin” style cooling arrangement. The pin style has been developed by Knorr and provides improvements in cooling capacity, reduction in hot spots, reduced parasitic drag, and reduced noise and pure tones as compared to the older “vane” style.

12.A.3.7 BRAKE PADS

The asbestos-free brake pads utilize a friction material which has shown stable friction characteristics under a wide range of temperature, humidity, and surface speed conditions.

12.A.3.8 TRACK BRAKES

The track brakes are a monoblock design. These track brakes provide a high attractive force and are used to augment the friction and dynamic brakes. The track brake equipment also includes the spring suspension assemblies.

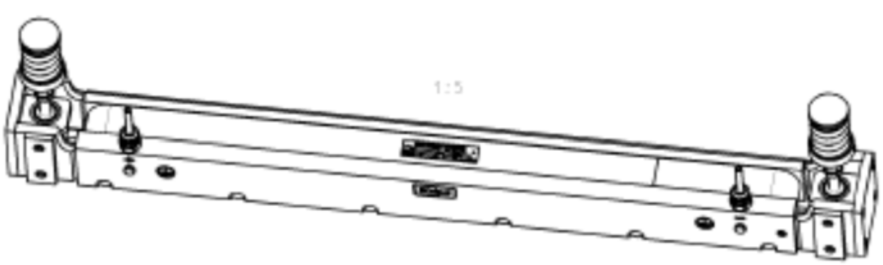
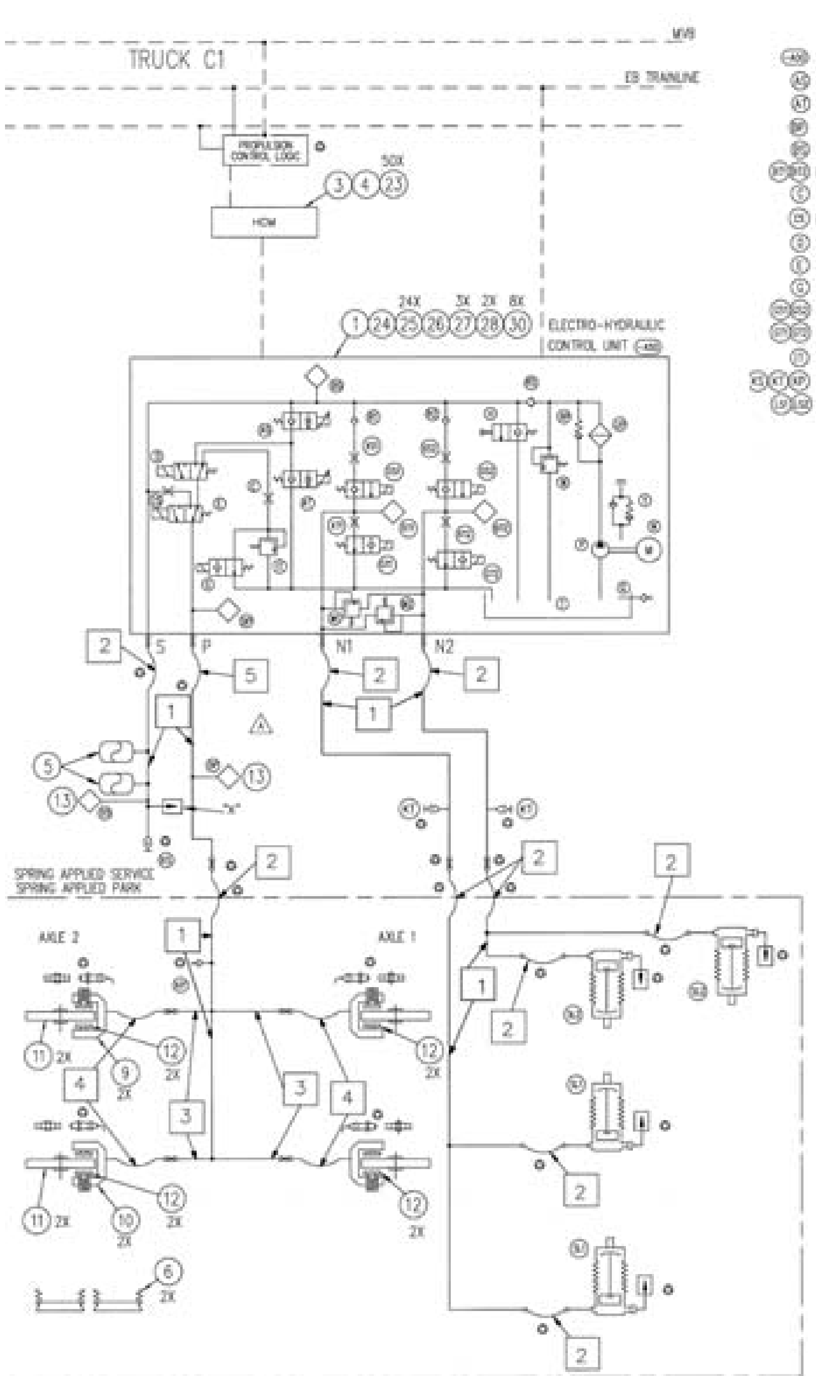


Figure 4. Track brake

12.A.3.9 HYDRAULIC DIAGRAM



Balloon	Description
1	EHU
2	ECU
3	Hydraulic Control Module
4	HCM interface connector
5	ACCUMULATOR 2.8L
6	TRACK BRAKE W/SUSPENSION
7	LINEAR LEVEL SENSOR
8	LINEAR LEVEL SENSOR Connector kit
9	BRAKE CALIPER LEFT PT w/SUPPORT BRACKET
10	BRAKE CALIPER RIGHT PT w/SUPPORT BRACKET
11	BRAKE DISC
12	BRAKE PAD LEFT / RIGHT
13	Pressure transducer
16	ECU connector MB038/2
17	ECU connector MB048/1
18	ECU connector EB01A/4
19	ECU MVB DB-9 MALE
20	ECU MVB DB-9 FEMALE
21	ECU power connector
22	Ethernet connector
23	Spring Contact
24	EHU control connector
25	Pins
26	EHU motor connector
27	CONTACT SOCKET 14-16 AWG
28	CONTACT SOCKET 4-6 AWG
29	Pins
30	Pins

Figure 5. *Hydraulic diagram (per truck)*

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Sub-Part A – VEHICLE DESCRIPTION

13 VEHICLE COMMUNICATION REQUIREMENTS

13.A. NARRATIVE PROPOSAL

13.A.1. COMMUNICATION AND CCTV SYSTEM

The CAF-provided vehicle will include a service-proven Communication and CCTV system which integrates the following sub-systems: Public Address (PA) system, Passenger Emergency Intercom System (PEI), Automatic Passenger Information System (APIS) and Closed Circuit Television (CCTV) system. All the subsystems have been designed and manufactured to work with railway rolling stock.

The Event Recorder (ER) system, Automatic Passenger Counting System (APC), Automatic Vehicle Locator (AVL) system, Traffic Light Priority System and Train to Wayside Communication (TWC) system are not integrated with the vehicle Communication and CCTV system.

The vehicle Communication System is based on a digital platform. The system is designed to operate in railway environments that require a high level of availability and follows the most complete interoperability requirements. This system is already operating in the CA- manufactured vehicles running in Cincinnati.

The most important functions regarding to the vehicle Communication are the following:

- Public Address to the passengers on board and on station platforms
- Cab-to-cab communication
- Passenger Emergency Intercommunication (PEI)
- Control of public address connections such as: Cab to/from PEI, Cab-Cab, Cab to Public
- Automatic audio and visual announcement of the current station, next station and transfer connections for the passengers onboard.
- Automatic audio and visual announcement of the route number and destination station for the passengers on the platform.
- Manually activated audio and visual announcement of special notifications regarding the service conditions of the units for the passengers onboard and the passengers on the platform.

The most important functions regarding to video surveillance system are:

- Images Storage from the onboard cameras.
- Rear View cameras images visualization over the Rear View TFT monitors.

The vehicle Communication and CCTV system is comprised of the following devices:

- 1 control unit PIS+CCTV
- 2 Communication Control Panels (integrated as an additional screen into the MDS HMI)
- 2 cab speakers
- 2 covert microphones
- 2 cab microphones
- 8 passenger compartment loudspeakers
- 4 exterior loudspeakers
- 4 Passenger Emergency Intercom Devices
- 2 front LED exterior displays
- 2 side LED exterior displays
- 4 interior LED displays
- 4 rear view 9″ monitors
- 4 rear view cameras
- 4 forward facing cameras
- 4 interior cameras

The vehicle communication system is a fully digital system based on Ethernet network.

The following figure illustrates the architecture of the system:

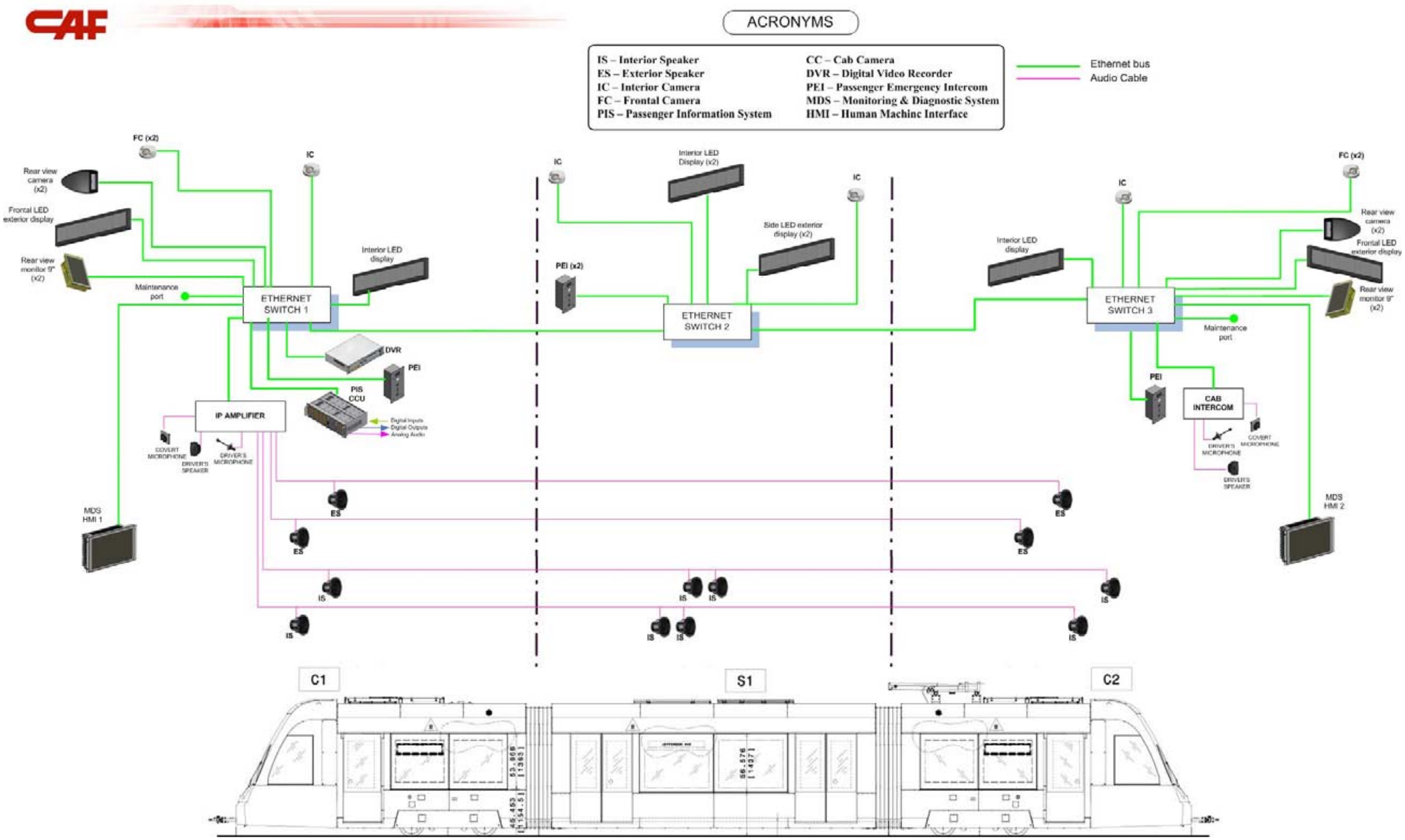

Figure 1. Communication and CCTV system architecture

The vehicle communication system is made up of subsystems distributed in the vehicle that manage the audiovisual functions. The Communication system consists of the following equipment.

PIS+CCTV Control Unit

There is one PIS+CCTV Control Unit (CU) per vehicle. The CU is the main equipment in the Communication System and is responsible for managing and controlling the rest of the Communication System's equipment. In addition, PIS+CCTV integrates DVR (Digital Video Recorder) equipment. It records images from the CCTV cameras which are stored in the CCTV server in a keylock-protected removable Hard Disk Drive (HDD) memory. The PIS+CCTV Control Unit is fitted with 2TB HDD memory.

Communication Control Panel

The Communication Control Panel (CCP) is integrated as an additional screen into the MDS HMI. The MDS HMI provides a communication control screen for the driver and is used to select the route and the public address connections to be made.

Saloon Speaker

There are eight (8) saloon speakers per vehicle. They are located within the passenger area. The saloon speakers are used for public announcements. They interface with the CU amplifier board.

Exterior Speaker

There are four (4) exterior speakers per vehicle. They are located on the outside, near the doors on both sides of the car. Exterior speakers operate when the doors are open and are used to broadcast public address announcements to passengers on the train station platform.

Passenger Emergency Intercom

There are four (4) passenger emergency intercom (PEI) devices in the vehicle. Their function is to allow two-way communication between the Train Operator and the passengers

Interior display

There are four (4) interior LED displays in the vehicle. The interior LED displays comply with ADA requirements for 12-character display. Those LED displays are located in the passenger area. The displays provide information such as the current station, next station, and destination.

Front exterior Displays

There are two (2) exterior front end LED displays per vehicle, located above the windshield on the frontal ends of the vehicle. The front exterior LED displays comply with ADA requirements for 15-character display. Those signs are embedded in the walls, facing outside to be visible to awaiting passengers on the station platform. The exterior front end destination signs display the train destination and run number.

Side exterior displays

There are two (2) side LED exterior displays in the vehicle. The side exterior LED displays have the same dimensions as front LED displays and comply with ADA requirements for 15-character display. Those LED displays show information such as the current station, next station, destination, stops list and other general information to passengers at platform stations.

Rear View Cab Monitor

There are four (4) 9″ Rear View Cab Monitors, two (2) per Cab. In those monitors the operator can check the activity outside the vehicle. The images come from the Rearview Cameras.

Forward Facing Interior Camera

There are four (4) Forward Facing Cameras, two (2) per Cab. Those cameras monitor the tracks when the vehicle is running. They are located next to the front end destination sign, at the upper part of the front end.

Interior Camera

There are four (4) Interior Cameras. Those cameras monitor the activity inside the vehicle. They are located so that they can cover all entry doors and seating areas.

Rear View Camera

There are four (4) Rear View Cameras, two (2) per Cab, installed on the upper sides of the Cab. Those cameras monitor the exterior of the train on both sides of the vehicle along the full length of the platform (high platform and street level).

Please refer to the following appendix documents for a detailed description of the vehicle communication system.

- Appendix 13.1 Technical Description PISPASPA_CCTV
- Appendix 13.2 Functional Description PISPASPA_CCTV

13.A.2. WARNING DEVICES

CAF will install a horn and a bell on each cab of the vehicle. The horn and the bell will be the same devices as those installed in Cincinnati vehicles. The horn is a multiple-tone electronic air horn and is comprised of the following equipment:

- Driver Horn Type-3
- Train Digital Sound Generator 200/25 (TDSG-200/25)

Detailed information about the Driver Horn Type-3 and TDSG-200/25 is presented in the following appendices:

- Appendix 13.3 Driver Horn Type-3

- Appendix 13.4 TDSG-200/25

13.A.3. RADIO EQUIPMENT

CAF will install in the operator's cab the radio equipment supplied by City of Seattle. CAF will provide the associated wiring and if required, will also provide the DC/DC power converter to provide the required power supply to the radio equipment. According to the City's Answer to Question 30, CAF has considered that the radio equipment is a standalone system, and that apart from the power supply interface, the radio has neither electric interface nor network interface with other vehicle equipment. Thus, CAF's proposal does not include any electric nor network interface development.

13.A.4. GPS RECEIVER

CAF vehicles will include a WAAS-enable GPS receiver integrated within the APC system. This GPS receiver will be used by several systems such as APC, PIS, CCTV, Event Recorder and MDS.

13.A.5. VEHICLE WIRELESS COMMUNICATION TO WAYSIDE

The vehicle will include a GSM/GPRS/UMTS/WLAN communication router integrated within the APC system. This wireless router will be used for wireless download of onboard Automatic Passenger Counting Data to the wayside servers when the train is on the route or in the depot areas (mobile operator coverage and Wi-Fi coverage is not CAF's responsibility). Any data plan with mobile operators is not in CAF's scope of supply.

CAF's proposal does not include wayside access points and wayside servers. CAF assumes that vehicle APC data will be downloaded with the existing City Of Seattle server and with the existing vehicle project wayside software.

13.A.6. EVENT RECORDER

The vehicle will include one Event Recorder (ER), model TELOC 1500. This event recorder is the same ER that has been installed in CAF supplied vehicles for City of Cincinnati. The Event Recorder is fitted with a Crash Protected Memory (CPM) Module that complies with the requirements of the American standard IEEE1482.1.

Please refer to the following appendix documents for a detailed description of the Event Recorder.

- Appendix 13.5 Event Recorder Technical Description
- Appendix 13.6 Event Recorder Functional Description

13.A.7. AUTOMATIC PASSENGER COUNTING (APC)

The vehicle will include an automatic passenger counting (APC) system IRMA Matrix with COPILOTpc2 based on Windows 7. The onboard APC system will automatically download APC data to the wayside using its own Wi-Fi router when the vehicle is in the maintenance shop and yard.

The proposed APC system is comprised of the following components:

- 1 COPILOTpc2
- 3 Ethernet switches
- 8 MATRIX APC sensors (one per door)
- 1 multiband antenna (GPS, GSM/GPRS/UMTS, WLAN)

The architecture of the onboard APC system is the following:

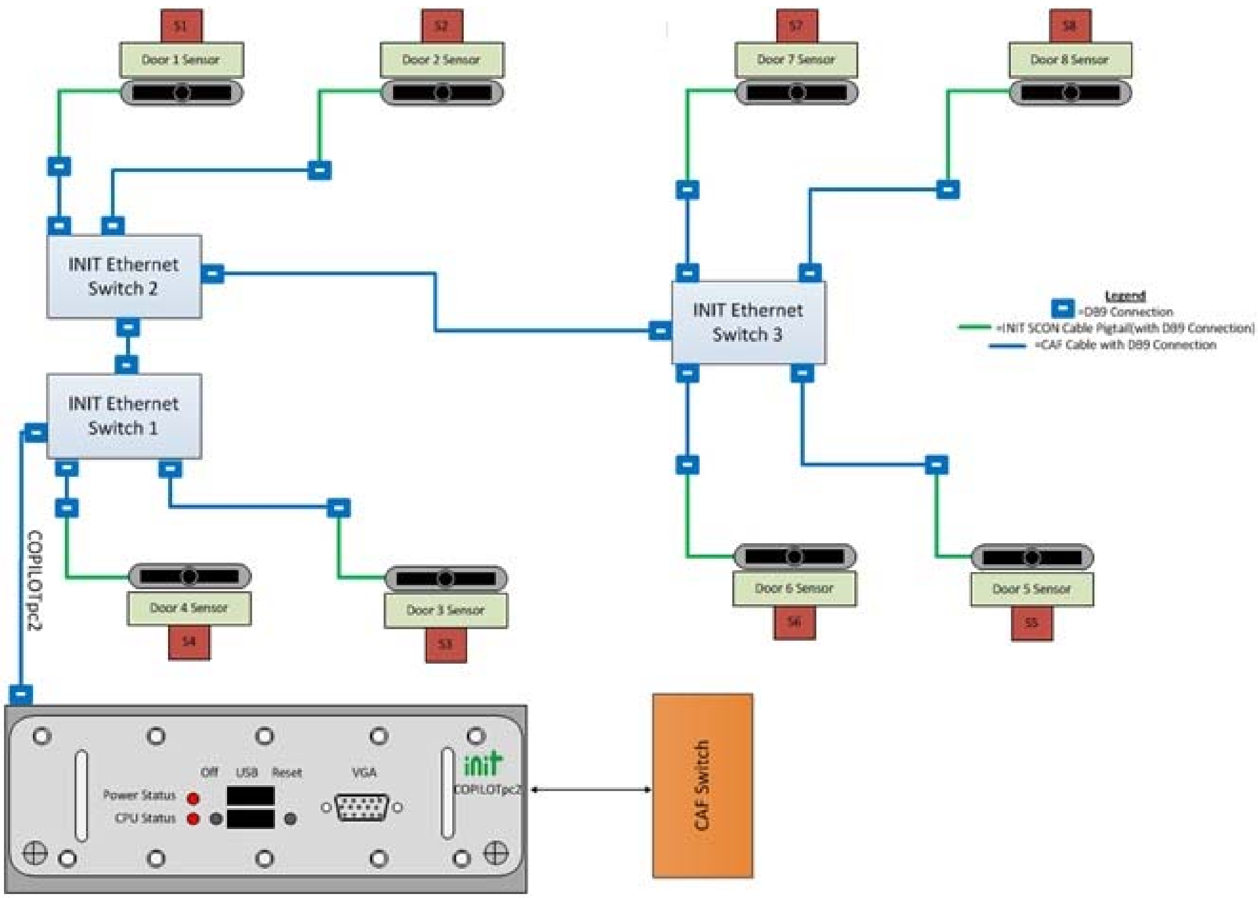

Figure 2. *Onboard APC architecture*

13.A.7.1 DESCRIPTION OF THE COPILOT PC2

The COPILOTpc2 is a vehicle logic unit (VLU), which is based on the Intel Atom CPU with x86 architecture. With the powerful CPU and ruggedized construction, the concept of COPILOTpc2 meets the requirements for the use within transit vehicles. The COPILOTpc2 has the same functionality as a PC, with many different interface capabilities, and switchable outputs and inputs. A com-pact format, which can be mounted in a 19-inch rack or a small mounting bracket, a highly integrated layout and the extended temperature range are the key features of the COPILOTpc2 and the basis for the use in rough areas.

Figure 3. *COPILOTpc2*

The COPILOTpc2 can handle different tasks in the vehicle. The main tasks are:

- Vehicle location tracking, e.g. via GPS and odometer signals
- Control of on-board peripheral devices e.g. next stop announcement
- Exoneration and support of the driver during operation
- Data transfer between the vehicle and the depot
- Data Communication between the vehicle and dispatch
- Communication between master vehicle and slave vehicles

13.A.7.2 IRMA 3D MATRIX

The new IRMA 3D sensor attained such good results that IRIS immediately improved the design by implementing a matrix with 500 image points instead of 4 detection pixels (IRMA 3D) to scan the detection area. The result is the innovative IRMA MATRIX.

Figure 4. *IRMA MATRIX sensor*

The IRMA MATRIX sensor makes use of infrared LEDs. It uses the phase difference between the transmitted and reflected/decoded signals and the runtime of the signals to calculate the distance between sensor and detection object. By measuring the distance for each of the 500 image points, the IRMA MATRIX sensor delivers the next generation of true three-dimensional images in real-time. The high number of image points allow for the most accurate count data, as well as precise distinction between passengers and objects. Since the sensor works like an IR camera and observes the door area, it recognizes the door cycle (door open vs. door closed) which means door contact cables are no longer required.

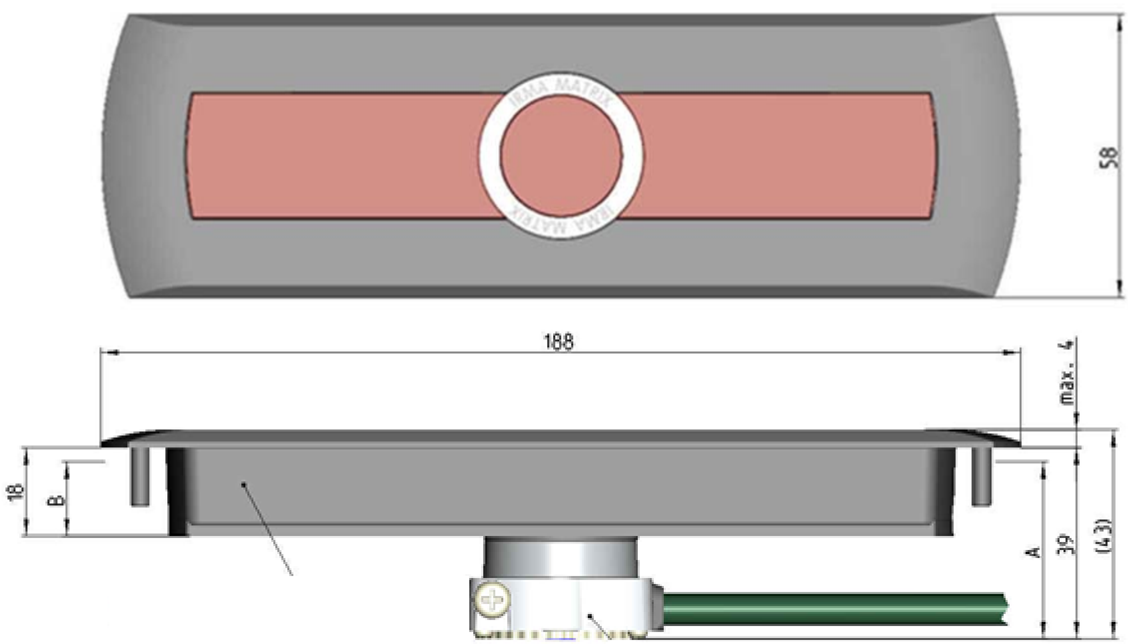

Figure 5. *Sensor Dimension*

The following figure shows the image of a passenger in a doorway as the sensor "sees" them in 3D view. The different colors indicate the distances from the sensor.

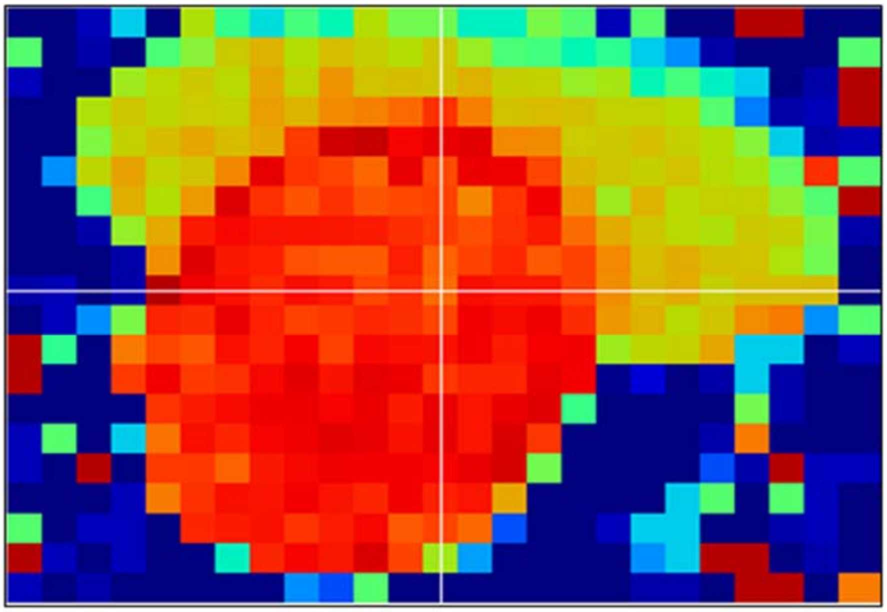

Image of Passenger in Doorway

Figure 6. *Visual of IRMA Matrix Doorway*

With IRMA 3D and IRMA MATRIX, individual body characteristics can be taken into account and individual persons are detected even when boarding or alighting in tightly packed crowds. This is also true when passengers are boarding and de-boarding simultaneously. The sensors have proven very reliable, especially when high accuracy of the raw “out-of-the-box” data is required.

The latest IRMA MATRIX sensor exemplifies the IRIS APC brand by producing the highest possible count accuracy achievable by infrared technology. In summary, the IRMA MATRIX sensor:

- Integrates the counting processor with signal processor by direct connection to on-board system.
- Works like a camera to “see” the door area.
- Adjusts easily to door conditions.
- Recognizes door status automatically.
- Eliminates need for door contact cables.
- Communicates directly through a switch-on/ switch-off message generated by the on-board system.
- Yields precise counting accuracy of 98% and above without on-board data manipulation.
- Supplies accurate raw data count eliminating use of presumptions or probabilities in reports.
- Provides accurate performance, independent of environmental conditions.
- Mounts flush or surface above door.
- Connects to onboard system via ETHERNET or CAN.

The technical features of the IRMA MATRIX are presented in the following table:

FEATURE	DESCRIPCION
Dimensions	built-in version 188 mm x 58 mm (width x height)
Weight	250 g (without iCon)
Housing	Aluminum housing Optical apertures are made of plastic (Makrolon)
Cooling	Passive cooling
Protection class	IP67 (with fitted iCon)
Interfaces	Ethernet or CAN
Connection	iCon (iris connector)
Wiring System	M12
Vehicle Integration	CAN / TCP / IP driver for standard operating systems
System Architecture	Integration via API (Applications Programming Interface; for Windows, Linux and OSX platforms available)
Power Supply	From the electrical system of the vehicle
Voltage	Normal 24 VDC
Power Consumption	6 W typical 9 W maximum

Table 1. *IRMA MATRIX technical features*

13.A.7.3 ETHERNET SWITCH

The Ethernet switch is a five- port Ethernet switch for mobile applications. It provides one incoming port and four outgoing port for INIT or third party Ethernet devices. It also provides battery voltage power supply over the other pins of the connectors. Because of the high vibrations in vehicles, the Ethernet switch does not use standard RJ45 connectors, but more robust SubDs with Quicklock™ housings.

Figure 7. *Ethernet Switch*

13.A.8. AVL

CAF will install in the vehicles the NextBus Driver Control Unit (DCU). Following the indications of NextBus, each vehicle will be fitted with just one DCU that will be installed in the C1 operator's cab (the other operator's cab of the vehicle, C2, will not include the DCU). The DCU integrates the AVL/GPS receiver and the mobile data terminal.

Figure 8. *NextBus DCU*

The NextBus DCU features an easy-to-use LCD touch screen. Operators have the option of selecting from predefined canned messages or customizing text messages. The list of canned messages can be customized. The text messaging capability is available when the vehicle is not in motion.

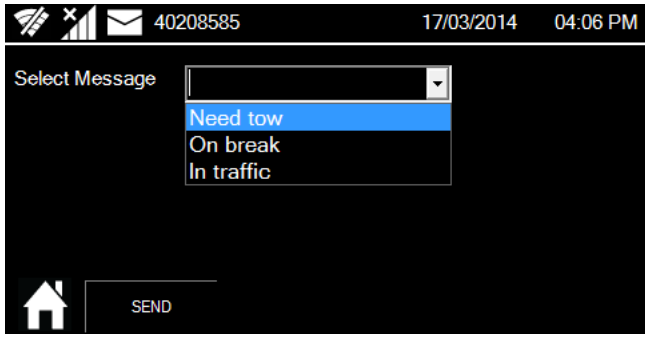

Figure 9. *Predefined Message Option*

Figure 10. *Keyboard for Text Messaging*

The NextBus DCU automatically sends a data packet to the wireless data network. These data packets will contain the vehicle ID, driver logon information and GPS fixes (e.g. speed, direction, and location).

Once in the network, the data packet is immediately routed to the NextBus database (not in CAF's scope of supply).

CAF provides the onboard NextBus DCU unit. CAF does not include in its proposal wayside equipment related to NextBus AVL system nor wayside NextBus software.

The required mobile coverage within vehicle route is not CAF's responsibility. Likewise, any mobile data plan with mobile operators is not in CAF's scope of supply.

Finally, CAF's proposal does not include AVL system related ASP (application service provider) charges nor any other Software License charges

The main features of the NextBus DCU unit are the following:

- Display: 480 x 272 pixels, 4.3" size LCD screen, touch screen.
- Integrated quad-band GSM/GPRS modem and GPS receiver
- Interfaces: 10/100 Base-T wired Ethernet, EIA-232, EIA-232/422, J1708/J1939 (CANbus), three USB 2.0 full-speed host ports.

13.A.9. TRAFFIC LIGHT PRIORITY

CAF will install on the roof of each vehicle cab the traffic light priority emitter supplied by City of Seattle. CAF will provide the associated wiring and will provide the required power supply to the traffic light priority emitter.

13.A.10. TRAIN-TO-WAYSIDE COMMUNICATION SYSTEM (TWC)

CAF will provide the onboard part of the VECOM Train to Wayside Communication (TWC) system. The vehicle will include one VECOM onboard TWC set per cab. Each TWC set is comprised of the following components:

- Vetag Code Control Box
- Vecom Transponder
- Vecom C Box
- Required cables

The required wayside TWC equipment is not included in CAF's scope of supply.

The TWC system sends a data message from the vehicle to the wayside and the wayside to the vehicle. The transponders are placed at each end of the vehicle, with mounting brackets and utilizing interconnecting cables and connectors. The Code Control Box will include four (4) push buttons and thumbwheels whose functions are determined by the truth table which is determined by the transit authority.

The main component of the onboard equipment is the Transponder which is activated by a Loop Antenna mounted in the road surface or rail track. When activated, the Transponder transmits a message to the Wayside equipment. The composition of the message depends on the truth table of the Code Control Box which is determined by the transit authority. To enable flexible programming, a Code Control Box can be used to enable the Operator of the vehicle to select predetermined messages.

13.B. DESCRIPTION OF SUBSYSTEMS AND COMPONENTS

The technical description of subsystems and components is presented in the previous section.

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SECTION 14 ELECTRONIC CONTROLS AND SOFTWARE

14.A. NARRATIVE PROPOSAL

14.A.1. VEHICLE NETWORK TOPOLOGY, PROTOCOL AND ARCHITECTURE

The main communication bus of the vehicle is the MVB bus (IEC 61375-3-1), which is based on the communication standard IEEE1473-T/IEC 61375-1 Train Communication Network. Most of the train systems are connected to it (except for information and communications equipment and CCTV equipment), as detailed in the following paragraphs. The HVAC, DCM (Desk Control Module) and Passenger Doors System are connected through CAN bus as consist networks for End Devices according to IEEE 1473-T (IEC 61375-3-3).

The specific communication network for the transfer of data associated with the information and communication equipment and with CCTV equipment in the vehicle is the Ethernet 10/100 BASE T network based on standard IEEE 802.3. Additionally, equipment from other suppliers is connected to the Ethernet network for the download of logs, configuration, maintenance, etc. The following figure shows the general schematic of train communications with the equipment connected to the Ethernet and MVB networks.

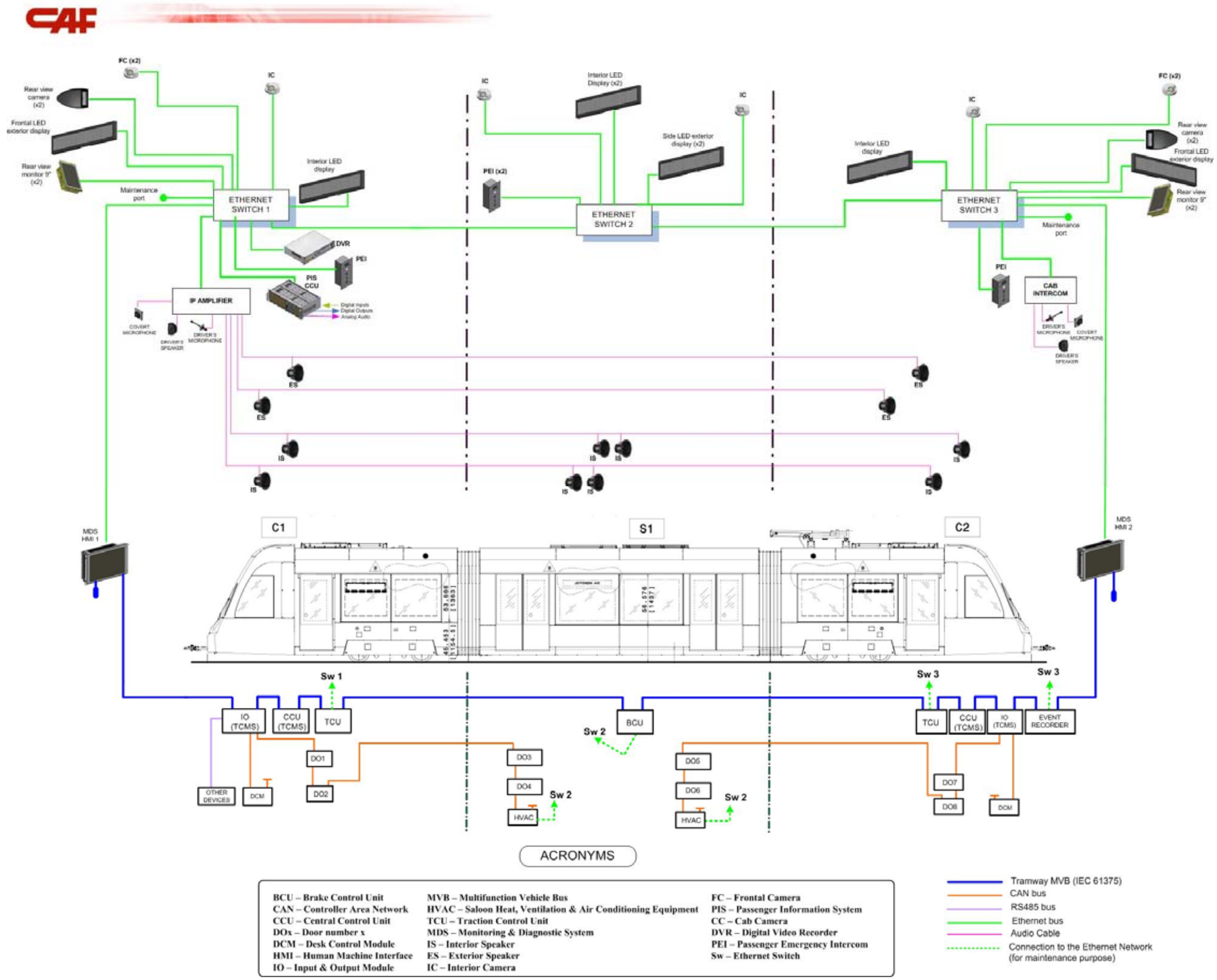


Figure 1. *General schematic of control and communications*

CAF will use hard-wired trainlines for safety-related control and monitoring functions and signals. Hard-wired trainlines will be used to implement functionalities related to vehicle safety and operational criticality. CAF considers that a hard-wired trainline has fewer failure modes than a network with subsystems, and is thus inherently more reliable and safe.

Train Communication Network

The architecture of the Train Communication Network is defined based on the IEC 61375-3-1/IEEE 1473-T International Standards. The Monitoring and Diagnostic System (MDS) is based on these standards. MDS modules are connected via MVB (Multifunction Vehicle Bus) network, as well as the rest of the main systems of the vehicle, such as:

- Event Recorder
- Traction Equipment
- Brakes
- Doors
- HVAC

Ethernet Network

Vehicle's Ethernet Network will be based on internationally accepted IEEE 802.3 100 Base-T standard Ethernet technology. This network will be used mainly by the communication system equipment and CCTV equipment.

Ethernet switches are installed in each car forming a central backbone network. Architecture of the network is based on 'ring architecture', so the vehicle ethernet network is able to recover communication in case of failure of one link of the backbone. The fault will be communicated to the MDS via data bus.

The following standard and open protocols will be used for the several communications that will be held in the Ethernet network installed in the train:

- IEEE802.3
- ARP RFC 826: Ethernet Address Resolution Protocol
- IP RFC 791: Internet Protocol
- DHCP RFC 2131: Dynamic Host Configuration Protocol
- TCP RFC 793: Transmission Control Protocol
- UDP RFC 768: User Datagram Protocol
- IGMPRFC 2236: Internet Group Management Protocol
- SNTP RFC 1361: Simple Network Time Protocol
- FTP RFC 959: File Transfer Protocol
- ICMP RFC 792: Internet Control Message Protocol

- SNMP RFC 1157: Simple Network Management Protocol
- RTP/RTCP RFC 3550: Real-time Transport (Control) Protocol

The network will assign the IP addresses automatically to the end-devices in agreement with their location in the train. The switches will implement a mechanism to determine the network topology and appropriately assign the IP addresses. The end-devices connected to the network will implement a DHCP client to get automatically the IP address, the subnet mask, the Gateway address and the DNS address.

The network switches will support static multicast configuration per port.

14.A.2. VEHICLE MONITORING AND DIAGNOSTIC SYSTEM (MDS)

CAF installs in the vehicle a Monitoring and Diagnostic System (MDS) known as COSMOS. This integrated system is a modular and expandable system based on the TCN standard IEC 61375-1, Second Edition, 2007-4 / IEEE 1473-T-2010. The proposed MDS is a service proven system.

All MDS's modules are designed and manufactured to operate in rolling stock, in compliance with current railway regulations. The system performs the following functions:

- Management of communication between vehicle's equipment. The system provides vehicle equipment with TCN-IEC 61375 communication channel (MVB bus) and manages all the information transmitted on the MVB bus.
- Interface with the vehicle via input/output channels and execution of vehicle control logic. The system has analogical and communication modules distributed throughout the vehicle which capture digital and analog variables through physical inputs and serial line communications, determine vehicle status and act according to the logic programmed in the TCN Control Unit (CU).
- Supervision, monitoring and recording of the vehicle's performance. The Human Machine Interface (HMI), besides being used to enter different vehicle driving and configuration parameters, displays in real time the status of each of the vehicle's systems. The MDS analyses malfunctioning conditions and displays them in real time in the HMI. Different operating faults are also recorded so that the vehicle attendant or maintenance personnel can act accordingly.
- Chronological register of event with environmental variables, in order to facilitate maintenance of the vehicle's systems. Recorded events may be displayed and analyzed on a computer external to the system.
- Control of auxiliary systems: The MDS performs non vital control functions on the vehicle, such as doors opening/closing, air conditioning, etc.
- The MDS also provides diagnostic capability within itself to detect a failure on any MDS processing node or MDS data communication network. In the event a failure is detected, the system automatically reconfigures the data communication network and continues its control and monitoring functions.

The MDS provides serial communication through the MVB bus to communicate with vehicle systems. Control, supervision, diagnostic and monitoring data is transmitted over the Multifunction Vehicle Bus (MVB).

The MDS includes programs for the PC that permit the development, debugging, and loading of the CU program and the downloading, analysis and display of the recorded data.

CAF uses hardwired discrete train-lines to perform safety related functions, control and monitoring of vital or safety-critical systems. The MDS system data communication network (MVB) is used for non-safety control, monitoring and maintenance functions. Vital functions are not performed by the MDS system.

The MVB bus provides 1.5 Mbps bandwidth and, thanks to its deterministic nature, permits real time transmission of control and monitoring data. Periodic data could be sent to any equipment with a real time performance of 32 ms without any loss of data packets.

MDS Data Communication Networks are based on accepted international standards. CAF believes that using international standards facilitates actual and future integration with equipment and systems in the vehicle consist. MDS architecture is illustrated in the following figure.

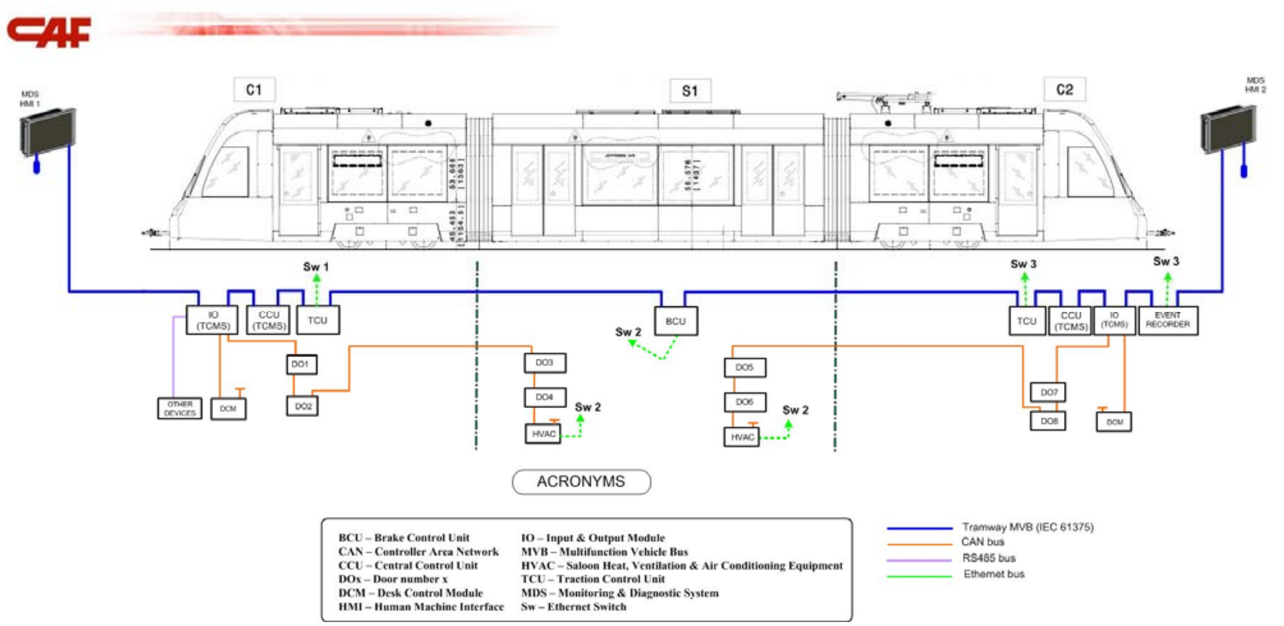


Figure 2. *MDS architecture*

CAF is the system integrator of the MDS. CAF has broad experience in designing and implementing TCN per IEC-61375. The System Integration is performed by the Systems Engineering Department, coordinated by the system Lead Engineer defined for the project.

CAF as System Integrator defines all interfaces between the vehicle Equipment and the Monitoring and Diagnostic System (MDS).

During the project stage, CAF programs the MDS, defining:

- All vehicle Data (Process Data, Messages Data, Special Variables etc.) that are exchanged over the MDS
- The vehicle Data Architecture
- When the vehicle Data should be transmitted

CAF provides to each Equipment Supplier the Specific Data that is exchanged between vehicle Equipment and MDS, so that to verify the communication requirements are correctly implemented in the Communication Tests (Communication Quality, Verification of the Data Application etc.).

The integration between vehicle equipment and the MDS includes the following tests.

1. Equipment non-functional tests

All vehicle equipment passes Non-Functional tests in order to verify Non-Functional requirements.

2. Equipment functional tests

All vehicle equipment passes Functional Tests in order to verify the Functionality requirements. These tests are held in the supplier's facility with the equipment that is installed in the vehicle.

3. Data communication test

Communication Tests verify that the Specific Data that is exchanged between vehicle equipment and MDS is correctly implemented (Communication Quality, Verification of the Data Application etc.). These tests are held in the MDS supplier's facility with the equipment that is installed in the vehicle (MDS along with the equipment itself).

4. Equipment functional tests in the vehicle

An Equipment Functional Test is performed in the vehicle. These tests are held in CAF's facility when all equipment is physically installed in the vehicle and logically integrated in the MDS as verified in the Definition of the Data.

5. On track functional tests

On track Functional Tests are the same as the Equipment Functional Tests, but these tests are held on track and in Real Service Conditions.

The function and characteristics of each MDS module fitted on the vehicle are explained below.

14.A.2.1 TRAIN CONTROL AND MVB BUS ADMINISTRATOR MODULE: CU/BA

The CU/BA module carries out a double function, a Bus administrator (BA) and control unit (CU). The operation of both of these is completely independent. This equipment is redundant as there is a CU/BA module on each end car.

The CU and BA functions control their redundancies in different ways.

- The BA controls MVB bus communications (master) during a 16s period. Once this period is over, the marker (bus master) shall pass to the other BA.
- For the CUs, by default there is a CU that shall operate actively (it runs the vehicle control logic), while the other shall remain as a passive CU. Should there be a problem with the active CU, the passive CU shall automatically switch to the Active CU and vice versa.

Bus Administrator Operation (BA)

Regarding a vehicle unit, the exchange of information between all the equipment connected to the bus must be controlled. This control is performed by the bus administrators (BA), in accordance with that specified in chapter 3 of standard IEC 61375-1.

The equipment bus function is fully autonomous, i.e. once the configuration tables have been loaded, each CU+BA equipment periodically executes the information transmission commands via MVB. The configuration tables for the modules contain the parameters of all the information transmitted via MVB, whether between COSMOS system equipment or between other equipment that shares the bus. This configuration must be in accordance with the configuration of each item of equipment connected to the MVB.

Control Unit Operation (CU)

On also performing the control function, the CU+BA modules execute the overall vehicle operation logic and control redundancies and decide which signals must be used at each moment.

On each unit, the CU+BA equipment with the control function active shall, according to the vehicle logic, detect the position of the driver, filtering the commands so that the other systems shall always only receive the commands from the enabled cab (if the implemented logic application so decides).

The CU+BA modules are fitted with an operating system which permits real time application execution. The applications can be programmed to operate in a cyclical manner. For each specific application or case, there can be a different number of cyclical tasks performed with different periods for improved SW organization.

There shall always only be a single CU+BA with active control function, while the other equipment shall be in a passive control condition, waiting for an intervention request, or should the first unit fail.

The main technical characteristics of the CU/BA are the following:

- 32 bit processor
- 2 Mbyte RAM
- 2 Mbyte Flash
- Real Time Operating System
- Battery voltage: 24 Vdc

CU/BA Maintainability

The module is inserted in an 84HP frame with a height of 3U. The equipment is connected to the vehicle battery via the connector mounted on the front, right hand part of the underframe.

All the CU equipment is functionally compatible, such that should a fault occur, it can be changed for another CU. The CU settings shall be defined as part of the system settings development performed by the project technical department, adapted to the requirements to be implemented.

14.A.2.2 CAB DISPLAY: MDS HMI

One 10.4” touch screen, TFT HMI is installed in the operating console of each cab. The HMI displays vehicle equipment operating status, diagnostic information and faults in real time as well as information related to maintenance functions.

The MDS HMI is the interface point with the system for the driver and the maintenance staff. By means of the various screens displayed via the MDS HMI, the personnel receive information regarding the vehicle status, and can interact with the HMI according to their privileges, configuration, and tasks defined by the system. All the relevant information and fault information is displayed to the driver on this screen, and the driver is able to operate functions and make requests.

The main functions of the MDS HMI are as follows:

- Vehicle status display: Pantograph, circuit breaker, door handle, etc.
- To display faults or incidents arising on any part of the vehicle and transmitted to the terminal via the corresponding communications bus.
- To display vehicle driving parameters (speed, distance travelled, wheel diameters, various voltage and current values, etc.).
- To record and monitor specific permanent parameters of each vehicle.
- To serve as an interface to enter commands that shall be transmitted to various items of vehicle equipment via the communication bus and the vehicle logic implemented in the CU.
- As an interface to monitor and diagnose equipment on the bus
- To record the varying degrees of faults/incidents/alarms
- To download files using external equipment (PC)
- Screen access restriction

A light sensor fitted on the front of the MDS HMI automatically adapts the screen brightness characteristics to the existing lighting conditions in the driver cab. This sensor provides optimum conditions for reading the contents of the screen with no external lighting as well as when the sun shines directly onto the driver cab.

The MDS HMI is equipped with a 128 MB compact flash where the permanent parameters and logs are saved, as well as other files required for application operation. This compact flash can be removed easily from the rear of the equipment, with no need for the use of a special tool.

The main technical features of the MDS HMI are:

- 10.4” TFT color screen with a resolution of 640x480.
- Real Time Operating System
- Touch Screen
- 256 Mbyte RAM
- 4 Mbyte graphic memory
- Consumed power: < 30 W
- Interfaces: MVB, RS485, USB, Ethernet

<u>MDS HMI Maintainability</u>

The MDS HMI is fitted with fixing supports to insert it into the desk. These supports can be easily accessed for assembly and dismantling should a fault occur.

All the HMI equipment is functionally compatible, such that should a fault occur, it can be changed for another HMI. The development of the HMI configuration and the graphical application is performed in coordination with the configuration of the COSMOS system and the CU logic. This allows the HMI to display the vehicle status, adapting to the project requirements and desired functions.

14.A.2.3 INPUTS / OUTPUTS MODULES: IO MIM MODULES

These modules contain different numbers of digital and analog input and output signal channels, as well as RS485/422 serial and CAN communication channels per communications module. Its main technical characteristics are the following:

- Interfaces:
  - MVB – EMD – Class2
  - Ethernet: M12
  - RS485
  - CANOpen
- I/O Interface Boards
  - 16-channel Digital Output Board (RELAY)
  - 32-channel Digital Input Board
  - 4-20mA 4 channel Analogue Input Board
- Self Test System.
- Consumption: According to the boards arrangement, lower than 30 Watt
- Supply options: 24 VDC, 72 VDC and 110 VDC
- Dimensions: 3U, 42HP , 230mm

I/O Module Maintainability

MDS IO modules are equipped with a power supply (DC/DC) that can be mounted on a rack, such that it can be accessed via the front of the underframe. This facilitates indicator visibility and access, easing tasks involving maintenance and replacement should a fault occur.

The equipment is also connected to the vehicle battery on the front via the DC/DC connector. This access eases maintenance tasks, whereby it is possible to check the status of the connectors by means of a quick procedure. The input and output connectors are also accessible from the front.

In general, everything is accessible from the front, therefore there is no need to make rear connections in the vehicle. As a result installation, equipment maintainability, mounting and removal is improved, should it be required due to a fault or if the unit is undergoing maintenance.

All the same type of I/O boards are functionally compatible, such that should a fault occur, a board of the same type can be replaced in any position by its equivalent. In other words, a faulty digital inputs board can be replaced with a replacement Digital Inputs board, without having to perform any preliminary software setting operations. The case is the same for digital output and analog input boards.

14.A.2.4 REPEATER

The repeater (RP) module has two main functions:

- Regenerates the MVB bus signal: The repeater module can detect noise in the signals it receives, and from these can generate and transmit equivalent signals with no noise.
- Detects the segments with permanent failure and isolates them from the rest of the bus.

The repeater module consists of two corresponding identical halves, each one to one of the two MVB bus's redundant lines (line A and line B). The supply is independent for both lines. This redundancy, as well as the repetition logic, prevents a simple fault in this module from affecting the TCN network's operation.

RP Maintainability

The module is inserted in an 84HP frame with a height of 3U. The equipment is connected to the vehicle battery via the connector mounted on the front.

All the RP equipment is functionally compatible, such that should a fault occur, it can be changed for another RP, with no need for preliminary configuration operations or SW load configuration.

Appendix 14.1 Communication_Interfaces is presents the architecture of the onboard networks and information of the devices connected to those onboard networks on a previous CAF project where similar vehicles have been provided.

Appendix 14.2 HMI_GUI_SPECIFICATION provides information of the MDS HMI graphic application implemented on a previous CAF project where similar vehicles have been provided. This appendix shows the screens available to the driver and maintainers as well as the top level screens management

concept to provide needed information to the driver while minimizing operator distraction when the vehicle is in motion.

CAF will provide a software tool to locally download the diagnostic system's log file. CAF-provided software would have to run in a laptop. The downloading would require the manual intervention of the maintainer by connecting the laptop to the onboard MDS.

CAF will provide the diagnostic equipment requested in TS 18.2.3. CAF will provide three (3) hardened laptops that will be fitted with configuration and maintenance software for the following systems:

- Monitoring and Diagnostic System (MDS)
- Propulsion system
- Friction brake system
- Auxiliary power supply
- Low voltage power supply
- Battery charger
- HVAC system
- Door control system
- Communications system

14.A.3. SOFTWARE CHANGES CONTROL, APPROVAL AND TRACKING PROCEDURES

Appendix14.3 Train_SQAP presents detailed information of CAF's approach to Software Quality Assurance Plan for the project.

14.B. DESCRIPTION OF VEHICLE NETWORK TOPOLOGY, PROTOCOL AND ARCHITECTURE

The vehicle network topology, protocol and architecture is described in the previous section – 13 Vehicle Communication Requirement.

CAFUSA

Exterior V1

Center City Connector Streetcar Design

City of Seattle

CAF USA

Exterior V1

Center City Connector Streetcar Design

City of Seattle

CAFUSA

Exterior V1 Alternative

Center City Connector Streetcar Design

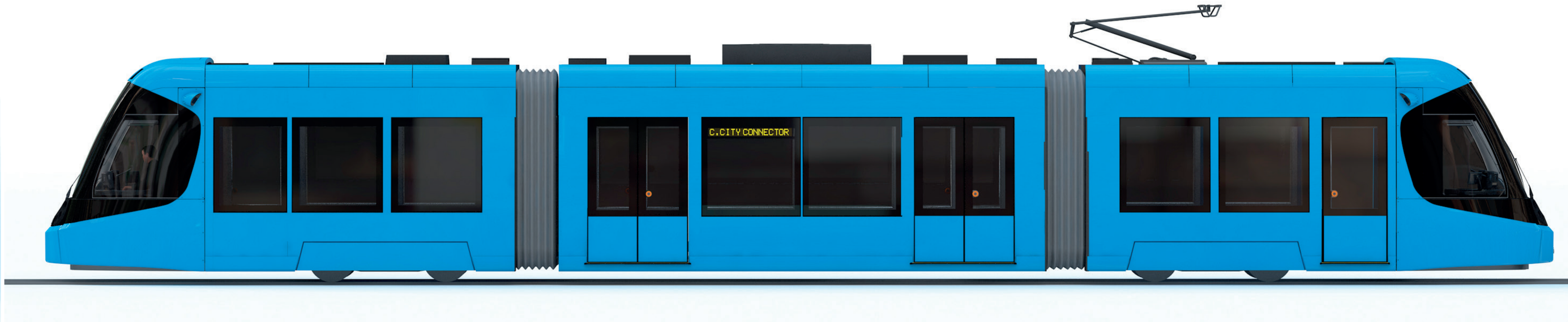
City of Seattle

Exterior V1 Alternative

Center City Connector Streetcar Design

CAF USA

City of Seattle



CAF USA

Exterior V2

Center City Connector Streetcar Design

City of Seattle

CAFUSA

Exterior V2

Center City Connector Streetcar Design

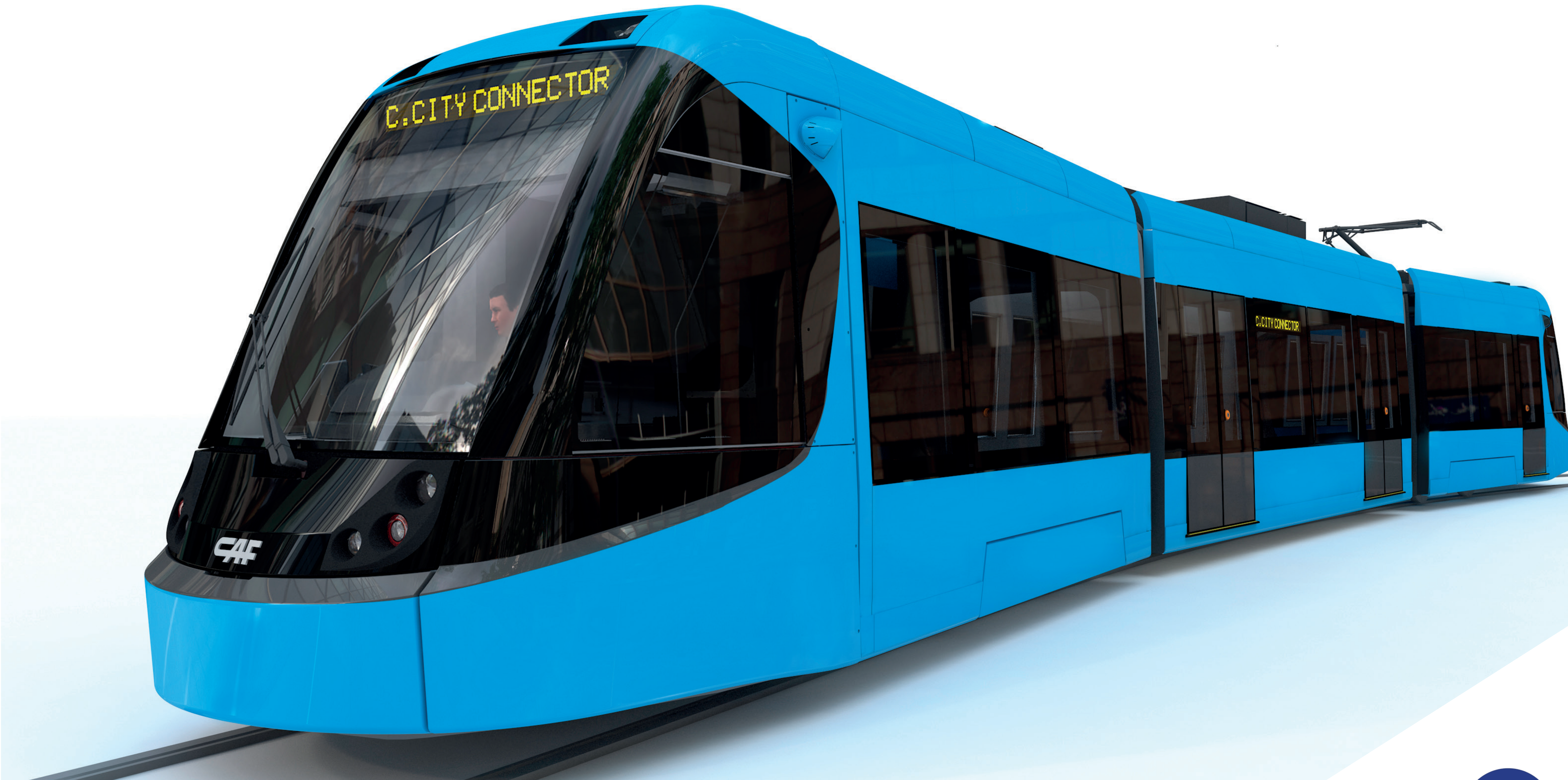
City of Seattle

CAF USA

Exterior V2 Alternative

Center City Connector Streetcar Design

City of Seattle



CAF USA

Exterior V2 Alternative

Center City Connector Streetcar Design

City of Seattle

Exterior V3

Center City Connector Streetcar Design

City of Seattle

CAF USA

Exterior V3

Center City Connector Streetcar Design

City of Seattle

Exterior V3 Alternative

Center City Connector Streetcar Design

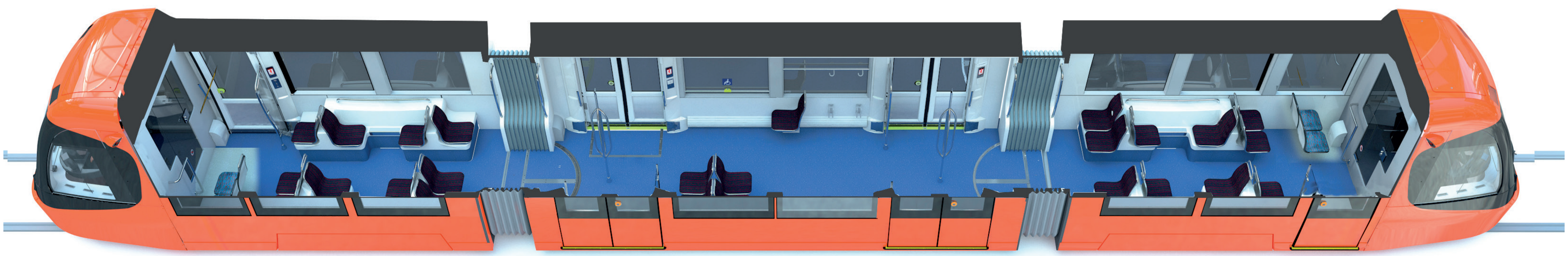
City of Seattle

CAF USA

Exterior V3 Alternative

Center City Connector Streetcar Design

City of Seattle



Section

Center City Connector Streetcar Design

CAF USA

City of Seattle

Interior V1

Center City Connector Streetcar Design

CAF USA

City of Seattle

Interior V1

Center City Connector Streetcar Design

CAF USA

City of Seattle

Interior V1

Center City Connector Streetcar Design

City of Seattle

Interior V1

Center City Connector Streetcar Design

City of Seattle

Interior V2

Center City Connector Streetcar Design

CAF USA

City of Seattle

Interior V2

Center City Connector Streetcar Design

CAFUSA

City of Seattle

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CAF USA

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City of Seattle

APPENDIX 1.3

RELIABILITY

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Sub-Part A – VEHICLE DESCRIPTION

1. INTRODUCTION

The aim of this document is to present the reliability requirements for the streetcar offered by CAF and to establish both the measuring conditions and the procedure to be followed for the compilation of information and Reliability calculation.

2. DEFINITION

Streetcar Reliability is measured by means of the MDBF index (Mean Distance Between Failures) and is calculated using the following formula:

$$MDBF = \frac{\sum_{j=1}^{n} K_j}{\sum_{i=1}^{n} G_i} \left[mile - streetcar / \ failure \right]$$

where:

- n: is the number of streetcars considered during the calculation period.
- Kj: for each streetcar, the number of miles travelled during the calculation period.
- Gi: for each streetcar, the number of service failures during the calculation period.

3. RELIABILITY TARGETS

The reliability targets are as defined in requirement SECTION 2.13 Reliability of the Design and Performance specification:

System	**MDBF** **(miles per car)**
Vehicle Body & Appointments, including seating, windows, cab equipment	40,000
Propulsion, Dynamic Brake & Controls including gear case	40,000
Friction Braking, including track brake and sanders	35,000
Communications and passenger information	75,000
Passenger Doors & Controls	25,000
Lighting Fixtures and Power Supplies / Ballasts	200,000
Electrical, including the vehicle network and cab controls, and apparatus not included in other systems. Excludes equipment internal to other	50,000
HVAC	60,000
Trucks & Suspension	100,000

Table 1. *City of Seattle's Reliability targets*

4. MISSION PROFILE

All reliability analyses are based on the following operating conditions:

- Mean annual distance per streetcar:......................................35,000 miles/year
- Mean daily switch-on hours per streetcar: .... 22 h/day
- Mean daily running hours per streetcar: .... 20 h/day
- Mean annual operating days per streetcar: ....365 days/year

The mission profile presented above allows defining these two Reliability Conversion Factors (RCFs) for the reliability analyses:

$$RCF_{Energised} = \frac{\text{Mean annual distance per train}}{\text{Mean annual operating days per train} \times \text{Mean daily switch on hours per train}} = 4{,}35 \text{ miles/h}$$

$$RCF_{Running} = \frac{\text{Mean annual distance per train}}{\text{Mean annual operating days per train} \times \text{Mean daily running hours per train}} = 4{,}80 \text{ miles/h}$$

Please note that if the operating conditions during the reliability demonstration period are more demanding than the above mentioned conditions the parties will adapt the reliability targets accordingly.

5. THE STATE OF THE ART

Other streetcar customers' Reliability requirements are analysed as well. Recent U.S. transit authorities' projects are taken as reference, specifically Valley Metro, Milwaukee, Detroit and Cincinnati ones, as the same reliability indexes and system aggrupation is considered.

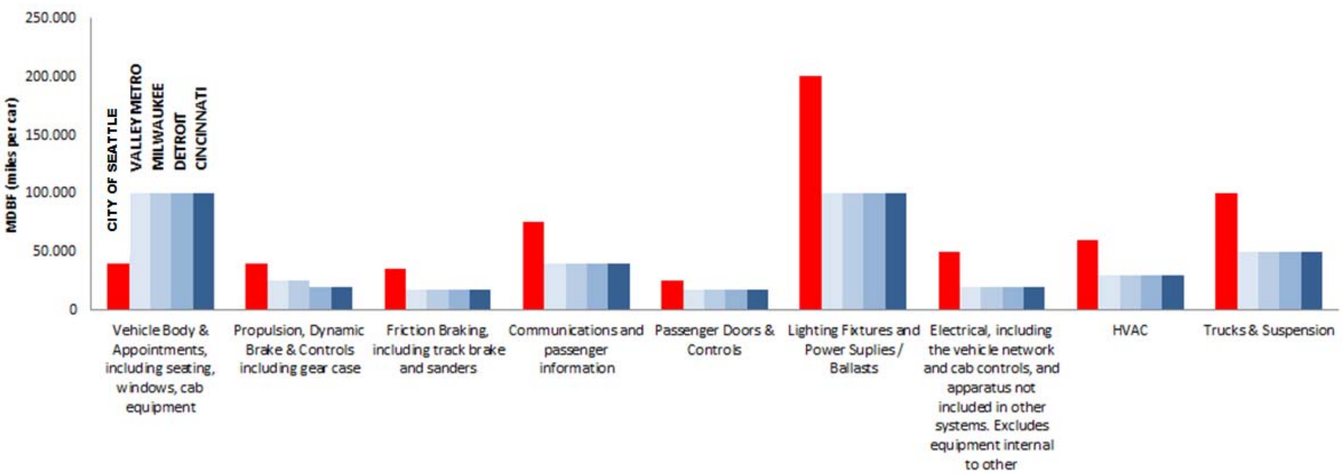

Figure 1. *MDBF requirements on USA streetcar projects*

As seen in the Figure 1, the values requested for City of Seattle are not in accordance with market parameters. The difference between the red bar (City of Seattle MDBF requirements) and the blue bars (the other projects' MDBF requirements average) is very significant; for most systems, the City of Seattle requirement duplicates the market reference.

6. RELIABILITY PROPOSAL

In conclusion, CAF will make a proposal for this project which is more in adherence with the U.S. market streetcar customer's requirements. The followings are the new values per system:

System	**MDBF (miles per fleet)**
Vehicle Body & Appointments, including seating, windows, cab equipment	100,000
Propulsion, Dynamic Brake & Controls including gear case	20,000
Friction Braking, including track brake and sanders	17,000
Communications and passenger information	40,000
Passenger Doors & Controls	17,000
Lighting Fixtures and Power Supplies / Ballasts	100,000
Electrical, including the vehicle network and cab controls, and apparatus not included in other systems. Excludes equipment internal to other	20,000
HVAC	30,000
Trucks & Suspension	50,000
ACR Energy Storage System	20,000

Table 2. *CAF's Reliability proposal*

7. RELIABILITY MEASUREMENT AND DEMONSTRATION

7.1 ATTRIBUTABILITY CRITERIA

CAF shall not be held responsible for faults resulting from the following causes:

- Accidents that cannot be attributed to the vehicle (the actual operation of the vehicle).
- Faults outside the service period.
- Faults resulting from or due to accidents
- Improper use or vandalism.
- Defective maintenance due to incorrect execution.
- Incorrect vehicle operation (by the driver or third parties not employed by CAF).
- Demands for beyond the limit performance, provided that such a demand is not due to other equipment on the vehicle itself.
- Faults not affecting on the headway
- Faults of equipment or items supplied by the Customer, or faults as a result of these.
- Consumable items faults which have not been timely replaced (as per the maintenance plan).
- Incidents where no fault with technical root is detected or which are not repeated during the following 3 days of passenger service.

- Faults which reoccur generate another fault because CAF was not allowed to perform the diagnostics and repair at customer facilities.
- Failures whose solutions are defined but cannot be implemented due to the need to wait for customer approval or the approval process.
- Failures caused by inadequate maintenance of the Units.
- Failures of (or caused by) way side infrastructure such as Network Provider (Internet), Track Signaling…
- Failures which, during corrective maintenance, cannot be verified to exist.
- Resets of electronic equipment in the following conditions: (1) the driver has all required information to reset the equipment on an individual basis (in the driver manual, cab terminal, etc.), or (2) the driver can perform a general shut-down and subsequent re-start of the Unit.
- Failures which, upon detection, are not reported to CAF on the same day of occurrence or whose report is inadequate to allow for efficient and timely corrective action.
- Failures caused by inadequate state, maintenance and/or clearance of the infrastructure.
- Unnecessary delays, service cancellations, passenger evacuations or rescues caused by lack of staff competence or knowledge of the Units.
- Any service affecting failure occurring in a Unit which is already in a state of fault due to a service affecting failure (attributable or not to CAF).

7.2 RELIABILITY DEMONSTRATION

Following the acceptance of each unit and before beginning the Reliability Demonstration Test, each unit shall run for three months without reliability controls. This stage is called burn-in and all the faults occurring in this stage are reported and recorded but shall not be considered in the Reliability calculation.

The fleet reliability measurement will be carried out each month on the basis of daily data, with 3 month-window (all attributable faults and the kilometers accumulated by the fleet in the last three months), and until 12 months after the commissioning of the last vehicle. The reliability calculation will be done for the fleet and the reliability targets are understood as fleet reliability targets.

Systems that fail to meet reliability goals during the demonstration period will be redesigned and retrofitted by CAF before the end of the warranty period, not implying this period’s extension.

APPENDIX 3.1

LOAD CASES

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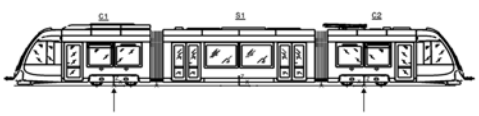
APPENDIX 3.1 LOAD CASES

The following load cases will be analyzed. Loads are defined in space with respect to the following coordinate axes: The X axis is the longitudinal direction of the car, the Z axis corresponds to the vertical axis, with positive direction upwards and the Y axis is along the longitudinal centerline of the car with positive dimensions to the right when viewing the car from the front of the C1 car, and negative dimensions to the left.

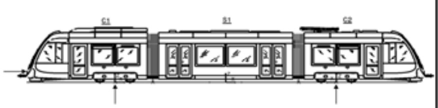
13.A. LC01 VERTICAL LOAD

AW4 passenger loading will be evenly distributed along the vehicle floor and reacted at the secondary suspension points.

Figure	Load	Acceptance Criteria
	Fz=W4CB	Stress in the carbody shall not exceed 65% of the material yield strength or 65% of the inelastic buckling strength, whichever is less.
		The floor beams shall not deflect more than 1/250 of the shortest span between supports up to a maximum of 0.170 inch.
		Analysis Method
		FEA Streetcar

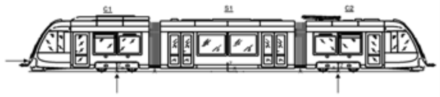
13.B. LC02 END SILL COMPRESSION LOAD

A longitudinal load equal to 90,000 lbf (400 KN), applied to the front of the cab anticlimber area (bigger than 0.15 m^2) and combined with vertical vehicle weight in tare condition.

Figure	Load	Acceptance Criteria
	Fx= 90,000 lbf Fz=AW0	Stress in any structural member, including sheeting, shall not exceed the material yield strength.
		At no point inboard of the coupler anchor shall the margin of safety be less than the lowest margin of safety outboard of the coupler anchor.
		The lowest margin of safety inboard of the coupler anchor shall not be in any part of the articulation or the yoke arms that attach the sections to the articulation.
		Analysis Method
		FEA Streetcar

13.C. LC03 COUPLER COMPRESSION LOAD

A longitudinal load equal to 110% of the release force of the coupler applied at the coupler pivot and combined with vertical vehicle weight in tare condition.

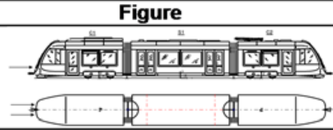
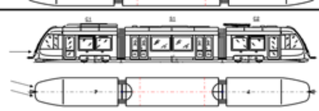
Figure	Load	Acceptance Criteria
	Fx= 49,500 lbf Fz=AW0	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.D. LC04 COLLISION POST

Collision Post shall be continuous through the end sill, extending from the bottom of the end sill to the structural shelf.

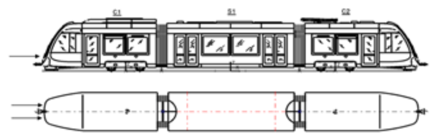
13.D.1. LC04.1 ANTI – TELESCOPING LOAD ABOVE FLOOR

Load of 18,000 lbf (80 KN) at 36 inches (915 mm) above the top of the rail applied in the longitudinal direction (inward) to each post, with both posts loaded simultaneously. Load direction variation permitted up to 15 deg in either side of longitudinal (inward). Longitudinal reaction loads will be applied at the opposite headstock and transverse reaction for the 15 deg offset load at truck to bogie connection. There shall be no permanent deformation of any structural member, structural sheathing or structural connection.

Figure		Load	Acceptance Criteria
a		Fx= 18,000 lbf Fz=AW0	Stress in the carbody shall not exceed the material yield strength
b			**Analysis Method**
			FEA Streetcar

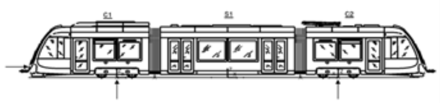
13.D.2. LC04.2 ANTI – TELESCOPING LOAD AT FLOOR

The minimum ultimate shear strength of each collision post shall be 56,000 lbf (250 KN) when the load is applied at a point even with the top of the underframe to which the post is attached. Longitudinal reaction loads will be applied at the opposite headstock and transverse reaction load at truck to bogie connection.

Figure	Load	Acceptance Criteria
	Fx= 56,000 lbf Fz=AW0	Resultant stress value will not exceed the ultimate strength of the material
		Analysis Method
		FEA Streetcar

13.E. LC05 STRUCTURAL SHELF

A horizontal structural shelf is provided below the windshield and connects the tops of the collision posts to the corner posts. The outer ends of the structural shelf are supported by the corner posts which are attached to both the underframe and the roof structure. A longitudinal load of 18,000 lbf (80 KN) is applied at any point in the longitudinal inward direction. Longitudinal reaction loads will be applied at the opposite headstock.

Figure	Load	Acceptance Criteria
	Fx= 18,000 lbf	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.F. LC06 CORNER POSTS

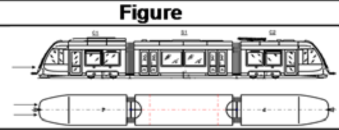
Corner posts are extended the full height from the underside of the end underframe to the roof rail.

13.F.1. LC06.1 CORNER POST, HORIZONTAL LOAD

An inward horizontal load in any direction from horizontal to transverse load of 9,000 lbf (40 KN) applied at 36 inches (915 mm) above the top of the rail is provided for two cases:

1. Load applied in the longitudinal inward direction
2. Load applied in the transverse inward direction.

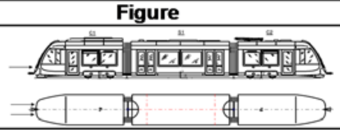
Longitudinal reactions will be applied at the opposite headstock and transverse reactions at the truck to carbody connection.

Figure		Load	Acceptance Criteria
a		Fx=9,000 lbf Fy=9,000 lbf	Stress in the carbody shall not exceed the material yield strength
b			**Analysis Method**
			FEA Streetcar

13.F.2. LC06.2 CORNER POST, ULTIMATE SHEAR STRENGTH

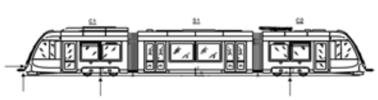
The minimum ultimate shear strength of each collision post shall be 17,500 lbf (78 KN) in any direction from longitudinal to transverse. If the post has a closed cross section, analysis is limited to the application of the load in longitudinal and transverse directions.

Longitudinal reactions will be applied at the opposite headstock and transverse reactions at the truck to carbody connection.

Figure		Load	Acceptance Criteria
a		Fx=17,500 lbf Fy=17,500 lbf	Stress in the carbody shall not exceed the ultimate strength of the material
			Analysis Method
b			FEA Streetcar

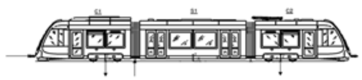
13.G. LC07 ANTICLIMBER LOAD

A vertical load of 1.1 times the static load required to raise the end of the vehicle, with the truck and running gear attached applied on the headstock lifting plates, combined with a longitudinal compressive load applied on the complete anticlimber area (bigger than 0.15 m2) of 60% of the end strength with no failures on the carbody. Replaceable energy absorbing elements may incur permanent deformation. Longitudinal reactions will be applied at the opposite headstock.

Figure	Load	Acceptance Criteria
	Fx= 54,000 lbf Fz=1.1 AW0	Stress in the carbody shall not exceed the material yield strength and the anticlimber will remain attached to the carbody structure
		Analysis Method
		FEA Streetcar

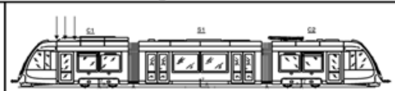
13.H. LC08 ARTICULATION JOINT ANTICLIMBER LOAD

A vertical load of 1.1 times the static load required to raise the end of the vehicle combined with a longitudinal compressive load applied on the anticlimber area (bigger than 0.15 m2) of 60% of the end strength with no failures on the carbody. Replaceable energy absorbing elements may incur permanent deformation. Longitudinal reactions will be applied at the opposite headstock.

Figure	Load	Acceptance Criteria
	Fx= 54,000 lbf Fz=1.1 AW0	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.I. LC09 ROOF LOAD

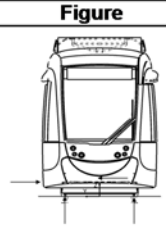
Three vertical downwards concentrated loads of 300 lbf (1330 N) distributed over a 12 inch (305 mm) by 12 inch (305 mm) spaced 30 inches (760 mm). Longitudinal and transverse distribution will be analyzed. Reaction load will be applied at the secondary suspension.

Figure		Load	Acceptance Criteria
a		Fz=3 x 300 lbf	Stress in the carbody shall not exceed the material yield strength
b			**Analysis Method**
			FEA Streetcar

13.J. LC10 SIDE LOADS

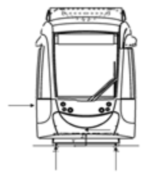
13.J.1. LC10.1 SIDE LOAD AT SIDE SILL

A transverse inward load of 40,000 lbf (180 KN), evenly distributed over the height and 8 ft (2,5 m) length of the side sill at the weakest location. (This load is supported at the truck attachment points and articulation points).

Figure	Load	Acceptance Criteria
	Fy= 40,000 lbf	Stress in the carbody shall not exceed the material yield strength or inelastic buckling strength. Local yielding of the sking adjacent to the side sill and belt rail shall be allowed.
		Analysis Method
		FEA Streetcar

13.J.2. LC10.2 SIDE LOAD AT BELT RAIL

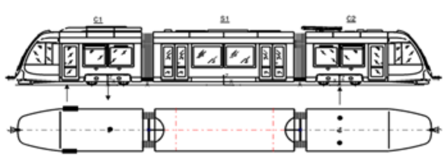
A transverse inward load of 10,000 lbf (44,5 KN), evenly distributed over the height and 8 ft (2,5 m) of the belt rail at the weakest location. (This load is supported at the truck attachment points and articulation points).

Figure	Load	Acceptance Criteria
	F_y= 10,000 lbf	Stress in the carbody shall not exceed the material yield strength or inelastic buckling strength. Local yielding of the skin adjacent to the side sill and belt rail shall be allowed.
		Analysis Method
		FEA Streetcar

13.K. LC11 RE – RAILING LOADS

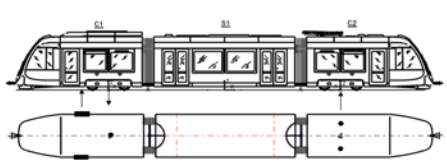
13.K.1. LC11.1 FRONT CAR C1/C2 RE-RAILING FROM LATERAL PADS (2-2')

Re-railing at AW0 condition from the two lateral pads with the truck attached and supported at the articulation.

Figure	Load	Acceptance Criteria
	$F_z= AW0_{CB}+ W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

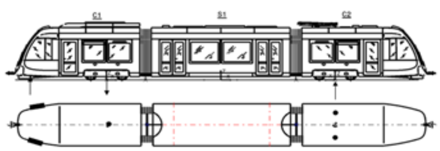
13.K.2. LC11.2 FRONT CAR C1/C2 RE-RAILING FROM LATERAL PADS (3-3')

Re-railing at AW0 condition from the two lateral pads with the truck attached and supported at the articulation.

Figure	Load	Acceptance Criteria
	$F_z= AW0_{CB}+ W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

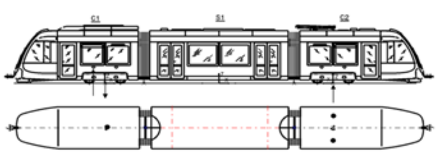
13.K.3. LC11.3 FRONT CAR C1/C2 RE-RAILING FROM CENTRAL PAD (HEADSTOCK)

Re-railing at AW0 condition from the two lateral pads with the truck attached and supported at the articulation. (Central Pad) located on center of headstock.

Figure	Load	Acceptance Criteria
	$F_z = AW0_{CB} + W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.K.4. LC11.4 FRONT CAR C1/C2 RE-RAILING FROM LATERAL PINS (A-A')

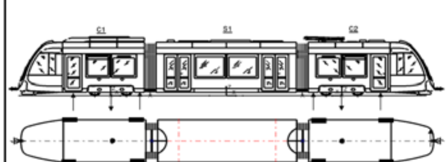
Re-railing at AW0 condition from the two lateral pins with the truck attached and supported at the articulation.

Figure	Load	Acceptance Criteria
	$F_z = AW0_{CB} + W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.L. LC12 JACKING LOADS

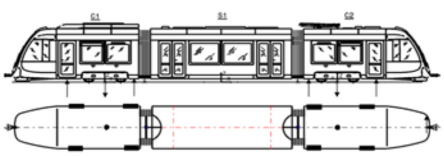
13.L.1. LC12.1 JACKING ENTIRE STREETCAR USING JACKING PADS

Jacking the entire Streetcar at AW0 condition including trucks using the 8 lateral jacking pads (2-2', 4-4',7-7',9-9').

Figure	Load	Acceptance Criteria
	$F_z = AW0_{CB} + 2W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

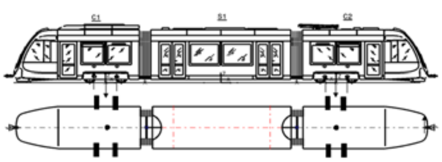
13.L.2. LC12.2 JACKING ENTIRE STREETCAR USING JACKING PADS

Jacking the entire Streetcar at AW0 condition including trucks using the 8 lateral jacking pads (3-3', 4-4',7-7',8-8').

Figure	Load	Acceptance Criteria
	$Fz= AW0_{CB}+ 2W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.L.3. LC12.3 JACKING ENTIRE STREETCAR USING JACKING PINS

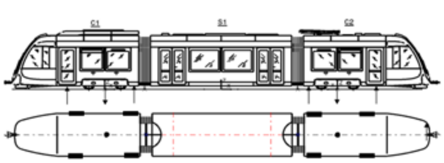
Jacking the entire Streetcar at AW0 condition including trucks using the 8 lateral jacking pins (A-A', B-B',C-C',D-D').

Figure	Load	Acceptance Criteria
	$Fz= AW0_{CB}+ 2Wmt$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.M. LC13 DIAGONAL JACKING

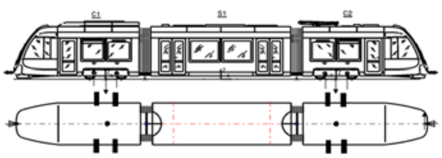
13.M.1. LC13.1 C1/C2 CAR DIAGONAL JACKING USING ENDMOST JACKING PADS (2-2')

Diagonal jacking at AW0 condition from end most jacking pads 2-2' with the truck attached and resting the complete Streetcar on pads (4-4', 7-7',9-9').

Figure	Load	Acceptance Criteria
	$Fz= AW0_{CB}+ 2W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

13.M.2. LC13.2 C1/C2 CAR DIAGONAL JACKING USING ENDMOST JACKING PINS (A-A')

Diagonal jacking at AW0 condition from end most jacking pins A-A' with the truck attached and resting the complete Streetcar on pins (B-B', C-C', D-D').

Figure	Load	Acceptance Criteria
	$F_z = AW0_{CB} + 2W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

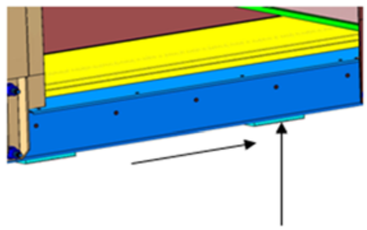
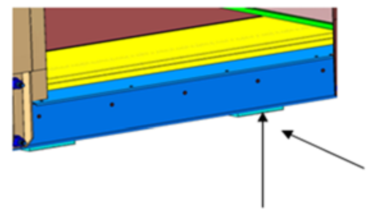
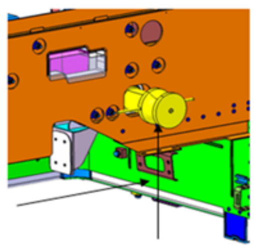
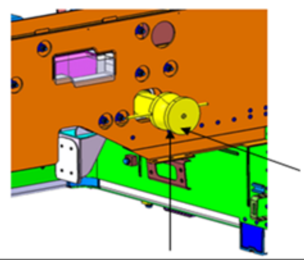
13.N. LC14 JACKING PADS AND PINS STRENGTH

13.N.1. LC14.1 JACKING

The carbody jack pads, jack pins and supporting structure shall be capable of supporting with a load factor of 2 an empty car at AW0 condition and truck attached in combination with a horizontal load of 10% of the vertical load applied at the bottom of the jack pad or jack pin in any direction.

(”F” is the maximum reaction value obtained in load cases 5.11 and 5.12)

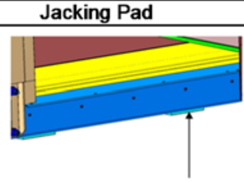
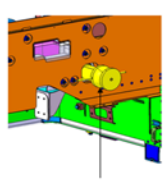
Figure		Acceptance Criteria
Jacking Pad		Stress in the jack pad, jack pin and supporting structure shall not exceed the material yield strength
a	Fz=2*F Fx=0.1*F	
b	Fz=2*F Fy=0.1*F	
Jacking Pin		
c	Fz=2*F Fx=0.1*F	
d	Fz=2*F Fy=0.1*F	**Analysis Method**
		FEA Streetcar. Analysis focused in the component

	
a	b
	
c	d

13.N.2. LC14.2 DIAGONAL JACKING

The carbody jack pads, jack pins and supporting structure shall be capable of supporting with a load factor of 1.5 an empty car at AW0 condition and truck attached.

("F" is the maximum reaction value obtained in load cases 5.13.1 and 5.13.2).

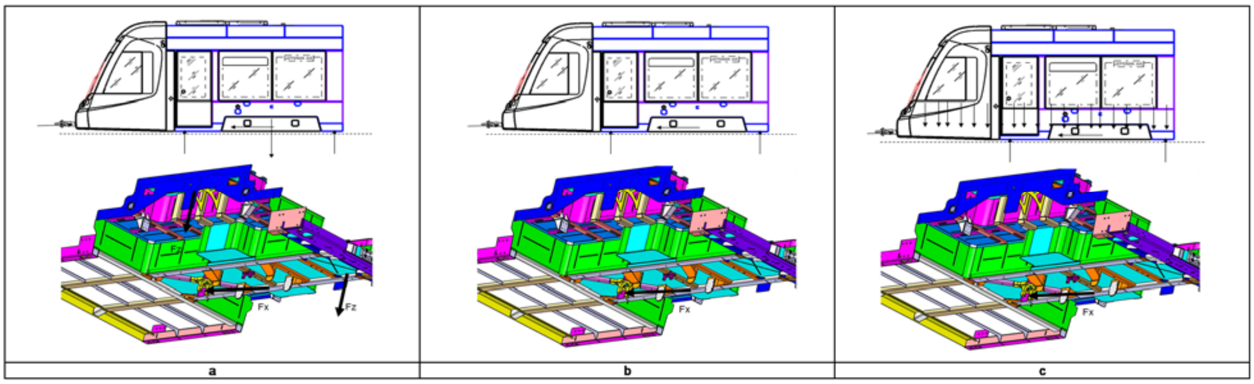
Figure		Load	Acceptance Criteria
Jacking Pad		Fz=1.5*F	Stress in the jack pad, jack pin and supporting structure shall not exceed the material yield strength
a			
Jacking Pin			Analysis Method
b			FEA Streetcar. Analysis focused in the component

13.O. LC15 TRUCK TO CARBODY ATTACHMENT

13.O.1. LC15.1 LONGITUDINAL LOAD

A load of 30,000 lbf (133 KN) applied longitudinally at the height of the truck centre of gravity at the lowest position of the vertical suspension travel, with different combination of vertical load.

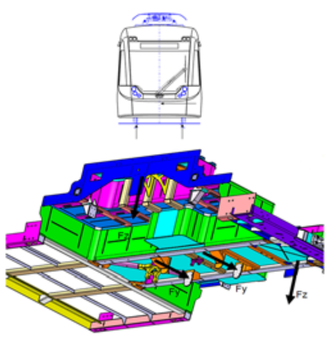
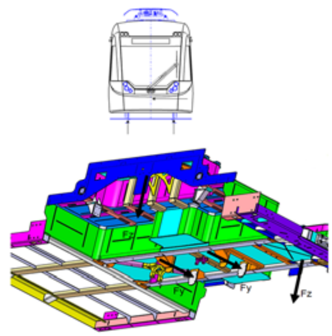
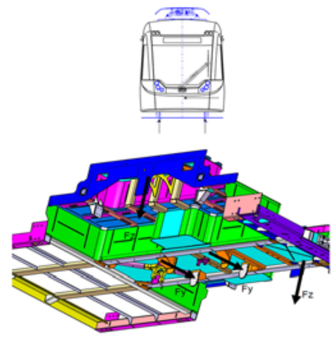
Figure		Acceptance Criteria
	Loads	
a	Fx=30,000 lbf Fz=WMT	Stress in the carbody shall not exceed the ultimate yield strength
b	Fx=30,000 lbf Fz=0	
c	Fx=30,000 lbf Fz=AW0	**Analysis Method**
		FEA Streetcar. Analysis focused in the component



13.0.2. LC15.2 TRANSVERSE LOAD

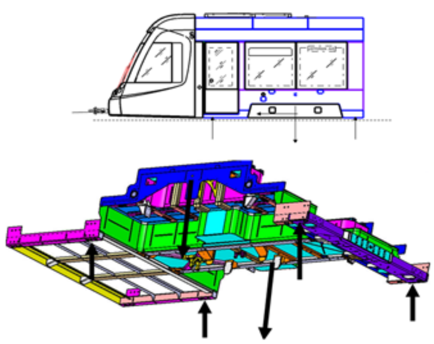
A load of 30,000 lbf (133 KN) applied transversally at the bogie transverse stops, with different combination of vertical load. Transverse reaction load will be applied on a rigid area of the side shell.

Figure		Acceptance Criteria
	Loads	
a	Fy=30,000 lbf Fz=WMT	Stress in the carbody shall not exceed the ultimate yield strength
b	Fy=30,000 lbf Fz=0	
c	Fy=30,000 lbf Fz=AW0	**Analysis Method**
		FEA Streetcar. Analysis focused in the component

		
a	b	c

13.O.3. LC15.3 VERTICAL LOAD

A load equal to two times the full weight of the truck.

Figure	Load	Acceptance Criteria
	$F_z = 2W_{mt}$	Stress in the carbody shall not exceed the material yield strength
		Analysis Method
		FEA Streetcar

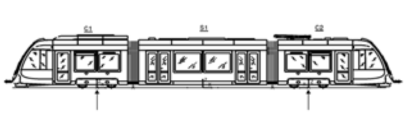
13.P. EQUIPMENT ATTACHMENTS

The information will be submitted in separate report.

13.Q. LC17 FATIGUE LOAD

13.Q.1. LC17.1 VERTICAL LOAD

The bodyshell structure will be designed to withstand the fluctuating loads due to whole body oscillations in response to track irregularities. For design purposes, this vertical loading with the body supported at the secondary suspension points, shall be assumed to be oscillatory with a mean value of AW2 less the truck weights and an amplitude of ± 20% (0.4 total dynamic range) for $N=10^7$ cycles.

Figure	Load	Acceptance Criteria
	$F_z=(1\pm0.2)\cdot AW2_{CB}$	Stress in the carbody shall not exceed the material fatigue strength for $N=10^7$ cycles
		Analysis Method
		FEA Streetcar

APPENDIX 13.1

TECHNICAL DESCRIPTION PISPASPA_CCTV

ISSUE CONTROL

ISSUE	REASON	DATE
- A	First issue Update attachment 1 (E-T02991) Include Request for Deviation ID 22 (approved in CINCAF 083) and ID23 (new). Update status of deviation requests.	19/APR/2013 13/NOV/2013

DISTRIBUTION

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Ignacio Olivera (Project Manager)
City of Cincinnati

Prepared by:	Revised by:	Approved by:
Name: J. Elena (SEPSA)	**Name** I.Pinilla(CAFTE)	**Name:** Miguel Artigas
Signature:	**Signature:**	**Signature:**
Date: 13/Nov/2013	**Date:** 13/Nov/2013	**Date:** 13/Nov/2013

INDEX

1 PURPOSE

The purpose of this document is to present, for City of Cincinnati review and approval, the Technical Description of the PISPASPA and CCTV Systems of the Cincinnati Streetcar.

2 ATTACHMENTS

Document	Issue	Date	Generated by
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ATTACHMENT 1. E-T02991 - Technical Specification - Communication and CCTV System - CAF / CINCINNATI CITY

Document E-T02991	Edition 05	Date 13/10/31

Technical Specification

Communication System (PIS-PAS-PA) & CCTV

Ethernet Network

CAF / CINCINNATI CITY

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CONTROL OF EDITIONS AND MODIFICATIONS

EDITION	MODIFICATIONS
00	Base Edition
01	Please, see modifications in document revision 2.
02	Please, see modifications in document revision 3.
03	Change of architecture (from 2 Control Units to 1)
	Changed housing model for RVC and FFC.
	Changed of EFI and ESI resolution.
	Modified: 3.2, 6.4, F.1.1, F.1.2, F.7.7, T.1.2, T.2.10, 8.3, T.8.1, 8.15
	Deleted: F.6.7, F.6.8, F.6.9 (edition 2 document numbering)
	Included 14.5
	Re-numbered figure numbers.
04	Removed chapters 9 to 14.
05	Added drawings references in chapter 3.1.-
	Added CAF documents in chapter 3.2.-
	Updated scope of supply in chapter 6.4.-
	Updated information about messages capacity in F.8.2
	Removed pictures and replaced with drawings references.

EDITION	DATE	PREPARED	CHECKED	APPROVED
05	13/10/31	Javier Elena	Félix Ruiz	Julio Rodríguez
04	13/04/17	Rodrigo Serrano Maeso	Pedro García Bachiller	Agustín Marín Vilallonga
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CONTENTS

1.- OBJECT

This Technical Specification defines the functional and technical requirements of the Passenger Information and Communication (PIS&PA), CCTV and Ethernet Network Systems all of them integrated in the Communication & CCTV System.

2.- SCOPE

This specification applies to the Communication & CCTV System, which will be applied to the new Streetcars manufactured by CAF for CITY of CINCINNATI.

The Communication & CCTV System will be, henceforth, named IRISD+CCTV System or System.

3.- APPLICABLE STANDARDS

3.1.- DOCUMENTS OF SEPSA-SCI

S064002	General Diagram
S064522	CONTROL UNIT (PIS+CCTV)
S064523	MICROPHONE
S064524	MICROPHONE PRE-AMPLIFIER
S064525	CAB SPEAKER
S064526	SALOON LOUDSPEAKER
S064527	EXTERIOR LOUDSPEAKER
S064528	INTERCOM
S064529	INTERNAL DISPLAY 12X96
S064530	EXTERNAL SIDE & FRONTAL INDICATOR 16X144
S064531	REAR VIEW MONITOR
S064533	REAR VIEW CAMERA IP
S064534	FORWARD FACING CAMERA IP
S064535	INTERNAL CAMERA IP
S064536	EXTERNAL POWER SUPPLY
S064537	COVERT MICROPHONE
S064538	SWITCH ETHERNET MODULE SWEM 16C
S064539	SWITCH ETHERNET MODULE SWEM 24C

3.2.- STANDARDS AND OTHER DOCUMENTS

EN 50121	Railway applications – Electromagnetic compatibility. Sep. 2000.
EN 50121-3-2, June 2001	Railway Applications Electromagnetic Compatibility Part 3-2: Railway Stock. Apparatus.

EN 50126	Railway applications. The specification and demonstration of Reliability, Maintainability, and safety (RAMS). September 1999.
EN-50155	Electronic equipment used on rolling stock.
EN-60297	Estructuras mecánicas para equipos electrónicos. Dimensiones de las estructuras mecánicas de la serie de 482,6 mm. (19”).
IEC 60529	Degrees of protection provided by enclosures (IP code).
IEC 60571	Electronic equipment used on rail vehicles. Feb. 1998.
IEC 61373, 1999-01	Railway applications – Rolling Stock Equipment – Shock and Vibration Tests.
IEC 61375-1	Electric railway equipment Train Bus Part 1. Train Communication Network Sep. 1999.
ISO/IEC 14496 MPEG4	Moving Picture Experts Group standard for video coding.
Q.41.94.161.01	TECHNICAL SPECIFICATION (EEFAE) PIS-PAS-PA SYSTEM (CINCINNATI STREETCAR)
Q.41.94.161.03	TECHNICAL SPECIFICATION (EEFAE) CCTV SYSTEM (CINCINNATI STREETCAR)
Q.41.94.500	General Technical Specification (CINCINNATI STREETCAR)

4.- DEFINITIONS AND ACRONYMS

ACH	Audio Control Head
CCTV	Closed-Circuit of Television. (Onboard Video Monitoring System).
CS	Cab Speaker
CT	Cab Terminal
CU	Control Unit
CPU	Central Processing Unit.
DVR	Digital Video Recorder
EB	Ethernet Backbone
EFI	External Frontal Indicator
EL	External Loudspeaker
EPS	External Power Supply
ESI	External Side Indicator
FFC	Forward Facing Camera
HD	Hard Disk
IC	Internal Camera
ID	Internal Display
INT	Intercommunicator, Intercom
IRISD	SEPSA-SCI’s digital Communications and Passenger Information

	System. (Onboard Emergency Interphones and Public Announcement System
LED	Light Emitting Diode
MDS	Monitoring and Diagnostic System.
MIC	Microphone
MMI	Man Machine Interface
MVB	Multifunction Vehicle Bus
OCC	Operating Control Center
PA	Public Address
PC	Portable Computer
PIS	Passenger Information System
PTT	Push To Talk
PTU	Portable Test Unit
PS	Power Supply
RHD	Removable Hard Disk.
RVC	Rear view Camera
RVM	Rear view Monitor
SL	Saloon Loudspeaker
SWEM	Switch Ethernet Module
TCMS	Train Control and Monitoring System
TCN	Train Communication Network
TOD	Train Operator Display
TU	Train Unit
VGA	Video Graphics Array

5.- RESPONSIBILITIES

The Project Manager is responsible for maintaining and updating this Technical Specification.

6.- GENERAL TECHNICAL DESCRIPTION OF THE SYSTEM.

6.1.- OPERATING CONTEXT

This IRISD+CCTV System will be installed in the new Streetcars manufactured by CAF for CITY of CINCINNATI.

The Streetcar is composed of three car body modules:

C1=S1=C2

Where:

C1/C2: body modules: Powered Truck leading modules with driving cabin.

S1: body module: Suspended middle module

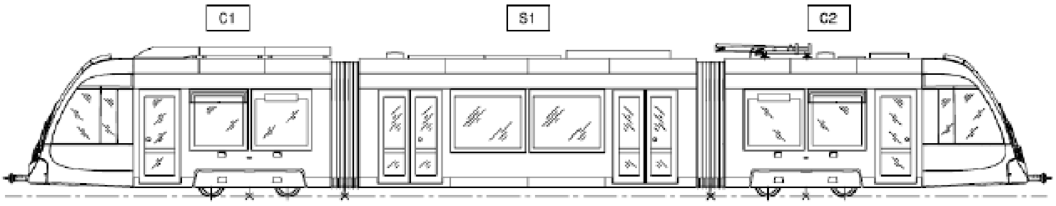


Figure 1 Streetcar definition.

The Streetcar will have eight passenger doorways, two per each C1/C2 module, and four in the S1 module. It shall be 24,4m long.

The Streetcar shall operate alone, not coupled with other Streetcars, or in a coupled configuration of up to two (2) cars in emergency towing. In any of these cases, the cab-to-cab intercommunication must be fully operative. All of the remaining system's functionality, excluding cab-to-cab intercommunication, will be unavailable in emergency towing.

The system will provide the Ethernet backbone network to be used by its own devices and for auxiliary equipment, and will interact with the TCMS via MVB bus and Ethernet communication.

6.2.- MAIN FUNCTIONS

The most important functions of the IRISD System are:

- Control of Public Address audio connections.
- Control of Intercommunication audio connections.
- Selection of the line and route to be covered by the train via MVB communication with the TCMS.
- Audio and textual announcement of the next station on the line, transfer connections, and other special messages associated with each station, for passengers onboard and on platform.
- Audio and textual announcement of special notifications regarding the service conditions of the units for the passenger onboard and on platform.
- Visual indication of train destination to the passengers on the platform and onboard.
- Support for configuration/change of lines and routes over which the train will travel.
- Control of audio level in each car depending on the ambient noise. Data received through data communication bus.
- Control of audio level in each car depending on the speed. Data received through data communication bus.

- Control of audio level in each car depending on the occupation (passenger load). Data received through data communication bus.
- Direct capture of discrete variables through physical inputs.

The most important functions of the CCTV System are:

- Video storage from the cameras of the train using recorders installed in the cars.
- Rear view camera's images visualization in cab rear view monitors.
- Removable hard disks in the recorder, for delayed viewing.

The most important general functions of the System are:

- Auto-check mechanism.
- Interface with the train's MVB bus.
- Ethernet Network management.
- Configuration of functional parameters.
- Integration with the TCMS.

6.3.- DESIGN ARCHITECTURE

The main characteristic of the IRISD+CCTV System is that it is based on a platform on the cutting edge of digital technology.

The System will carry out the transport of acoustic audio signals via Ethernet.

The System's digital technology allows not just the most conventional Intercom and Public Address functions, but also applications such as conversation recording, and any other activity associated with voice over IP processing.

The System is equipped with cameras for CCTV function. The System will store and display the images received from these ones.

Color cameras will be installed in each car, covering the entire car. Cameras will be equipped with automatic white balance, so that they can adapt to different light conditions.

The audio information is digitalized using signal processors (DSP) with the highest quality compression and equalizing technology.

The System is designed to work in railway environments with the highest level of availability and compliance with standards.

In this sense, the System has been designed following the most complete interoperability requirements.

This is an architecture aimed specifically at the railway environment, with high-quality and specific components that fulfill the demands of the environment.

The Control Units are specifically designed to operate normally under the special conditions of noise, vibration, etc. that are generate inside the train. The Control Units will be equipped with a specific embedded operating system, with the advantages that this provides over a generic operating system: stability, performance, fast recovery and boot times, etc.

The Control Units will be interconnected by S-FTP, CAT-5e or higher, 100 MHz cable, and will pass between cars over the connectors and patch cords required to comply with the certification. The installation of this cable will be certified with category 5e.

Under no circumstances may the total length of a point-to-point Ethernet link exceed 100 meters. In the case of Schafenberg coupling, the distance between points must not be more than 20-30 meters. We recommend shielded conduits for Ethernet wiring.

We recommend shielded conduits for Ethernet wiring.

6.4.- SYSTEM ARCHITECTURE

The System's architecture is represented in drawing S064002-E.

The System will be made up of the following equipment.

- Control Unit.
- ~~Switch Ethernet Module (SWEM) T1.~~
- Switch Ethernet Module (SWEM) T2.
- Cab Microphone.
- Covert Microphone.
- Intercommunicator (INT).
- Loudspeakers (cab, saloon and exterior)
- External Front Indicator (EFI).
- External Side Indicator (ESI).
- Internal Display (ID).
- Cameras.
- Rear View Monitor (RVM).
- External Power Supply (EPS).

The **Control Unit** (CU) is the main equipment in the System and is responsible for managing and controlling the rest of the System's equipment.

The Control Unit will carry out the following principal functions:

- Management of the Public Address Control.

- Intercom Control.
- Audio Broadcasting.
- Station Announcement.
- Display Control.
- Video capturing.
- Video recording.
- Ethernet data communication.
- MVB data communication.
- Direct signals acquisition.
- Self-testing.

The Control Unit will interact with the **ACH (Audio Control Head)**, so that the driver can establish the audio connections, by means of digital inputs acquisition and digital output control.

The Control Units will provide a connection with the MVB network of the train to provide connection to the rest of the train's systems, for example, with the TCMS, to send, for example, diagnostic data, etc. or to receive any type of information that is required for the System to function.

The **Cab PA&PIS Speaker** and **Microphone** permits to the operator to carry out:

- Cab to Passengers communication
- Cab to Cab intercom
- Cab to INT intercom

The Microphone is provided with a pre-amplifier.

The **Cab Radio Speaker** permits to the operator to hear the Radio incoming communication.

The **Saloon Loudspeaker** (SL) and the **Exterior Loudspeaker** (EL) broadcast the PA audio communication messages and the station announcer audio messages to people on-board and on the platform respectively.

The **Intercommunicator** (INT) acts as the Human-Machine interface between the System and the passengers, and its function is to allow two-way communication between the driver and the passengers.

The **External Front Indicator** (EFI) acts as the Human-Machine interface between the System and people on the platform of the station. They display information like, i.e., train destination and train run number.

The **External Side Indicator** (ESI) acts as the Man-Machine interface between the System and people on the platform of the station. They display information of the train destination and train run number.

The **Internal Display** (ID) acts as the Man-Machine interface between the System and people on-board. They display automatic, route related text messages, and manually activated ones.

The **Cameras** will permit to acquire the images which will be recorded and display.

The **Rear View Monitor** (RVM) is the main Man-Machine interface between the driver and the side rear view cameras, and it is used to display the cameras images. The image shall be mirrored to simulate the image seen on side mounted mirrors. There are two RVM in the driving cab mounted on the left and right side of the cab console.

The **Covert Microphone** will capture the ambient audio inside of the train control cabins.

The **Switch Ethernet Module** (SWEM) will permit connection to the Ethernet Network of the train.

Through the Control Unit and the Switch Ethernet Module, the System will be capable the management of the traffic of the network, as well as the address managing.

The **External Power Supply** (EPS) will feed up several devices of the System.

Each car is connected to the next car through an Ethernet connection, forming a train Ethernet network, to create a “physical” link between all of the equipment connected to the Ethernet network.

The Ethernet connections of the IRISD+CCTV System, of a car and between different cars in the TU will be done by the Ethernet Switch board in the Control Unit and the Ethernet Switch Module.

Unlike normal Ethernet switches, the Ethernet Switch used in the Control Units and the Switch Ethernet Module are equipped with a safety mechanism in the connections between cars that, in case of a complete failure of the switch, the Ethernet connection will be bridged (in its car), allowing the rest of the systems in the other cars on the network to function correctly.

All available Ethernet connections on the train provided by the IRISD+CCTV System are configured at 10/100Mbps.

The figure below shows the star wiring arrangement of the train unit Ethernet Network.

Groups of devices belonging to the System will be connected in Daisy chain arrangement, with a device connected to a single port of the switch, and the other ones connected serially to it. Each device’s internal switch will have a fail safe mechanism, so that the Ethernet connection will be bridged, allowing the rest of the

devices to function correctly.Devices not belonging to the System will be connected to a single port of the Swich.

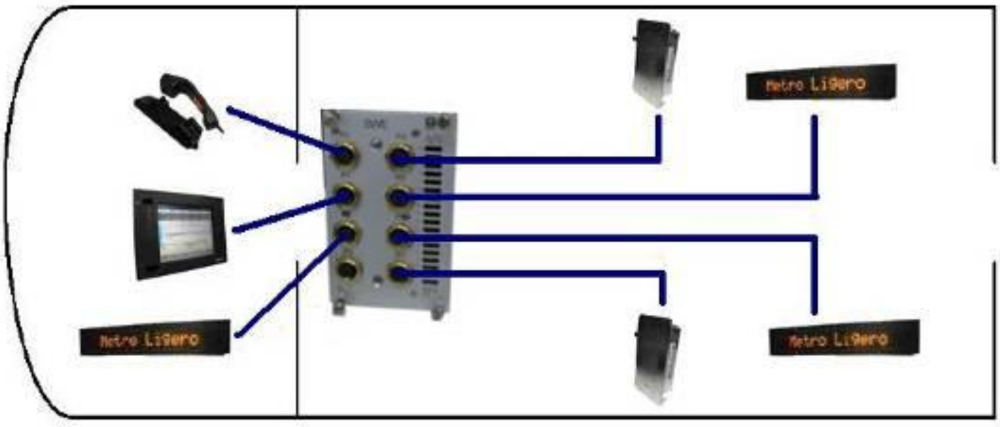


Figure 2 Ethernet wiring architecture. Star arrangement

The System is based on fully digital technology, including the intercom.

All of the voice conversations that are generated (by the driver, passenger, ground personnel, etc.), which, by nature, are analogue signals, are digitized when they enter into the System. The signals are digitized in the same unit where the audio is picked up, for example:

- **Intercom**: It converts into the digital format the voice conversation generated by the passenger.
- **Control Unit**: It converts into the digital format the analog audio signals connected to its analog audio inputs.

Once the information is in digital format, it will be sent to their destinations, whether in the car, to a different car, over the Ethernet network.

Once the information reaches its destination, the digital conversation is converted to analogue, with this conversion also taking place in the last equipment in the chain.

This System architecture makes it possible to transfer all voice communication without a quality loss from the point of origin to the destination, regardless of the length of the wires or the physical separation between the cars in which the communication takes place.

The CCTV System will provide digital IP cameras.

The Control Unit will perform the CCTV function to record the images of the cameras. In order to carry out these functions, the Control Unit will be equipped with a CPU and RHD boards where all the video images will be stored.

In the cars where there are not Control Units, Switch Ethernet Module will be installed in order to capture the images of cameras and to send them to the Control Units where they will be recorded.

The videos of the cameras will be recorded in **H.264** format.

The IRISD + CCTV System will generate data traffic of about 22 Mbps in the Ethernet Network.

The different types of boards with which the Control Unit is equipped, along with a brief description of the associated functions, are:

- PS: Power Supply. It converts the battery voltage to the internal voltages required by the System.
- I/O: Digital Inputs and Outputs.
- SWE: Ethernet Switch. Responsible for all of the Ethernet connections of the IRISD+CCTV System equipment and equipment from other systems.
- MVB CL2: Class 2 MVB card, allows the System to connect to the MVB bus.
- PA&PIS CPU: Central Processing Unit of the Intercom and Public Announcement System and Public Information System (PIS), responsible for Control and functions.
- AMP: Power Amplifier, to supply audio to the speakers.
- AM: Audio Matrix, responsible for making the audio connections.
- CCTV CPU: Central Processing Unit of the Video Recording System, responsible for managing to record the images of the cameras in the HD.
- CCTV HDE: Store the video captured in a HD.

The following table shows the distribution of the System equipment for a Streetcar:

Devices	C1	S1	C2
Control Unit	1	0	0
Intercom INT	1	2	1
External Front Indicator (EFI)	1	0	1
External Side Indicator (ESI)	0	2	0
Internal Display (ID)	1	2	1
Cab Microphone with pre-amplifier	1	0	1
Cab Speaker	2	0	2
Saloon Loudspeaker	3	4	3
External Loudspeaker	2	0	2
Internal Camera	1	2	1
Forward Facing Camera (FFC)	2	0	2
Rear view Camera (RVC)	2	0	2
Rear View Monitor (RVM)	2	0	2
External Power Supply	0	1	0
Switch Ethernet Module T2	0	1	1
Covert microphone	1	0	1

The System also includes:

- The hardware (Audio Capture Card plus Microphone) and software, to be

installed in a Maintenance Console PC of the OCC, for audio capturing and digitalization for the Automatic Announcement System as well as the software to edit the Station Announcer Data Base to allow the Authority the ability to record and up-load new announcements without the need for Contractor support.

- The hardware CCTV's HD off-line video extracting/reading equipment and the software to view and analyze the images recorded on the removable hard disks on the Maintenance PC. The CCTV's HD off-line video extracting/reading equipment must be connected to the Maintenace PC and the correponding SW must be installed in these computers.

- Maintenance PC programs needed to download and viewing the videos recorded in the Hard Disks of the Control Units or viewing the images in real time connecting locally the PC to the Control Unit.

- PC program needed to perform the Portable Test Unit PTU functions. This program will be able to perform the PTU functions on a laptop connected locally to the on board Control Unit through Ethernet. The PC for the PTU is not in the scope of supply of SEPSA SCI.

The following table lists the additional HW included in the scope of supply of the system:

Devices	Quantity
Audio Capture Card for PC (to be isntalled in the Maintenance Console PC of the OCC)	2
Microphone for the Audio Capture Card (to be installed in the OCC)	2
CCTV's HD off-line video extracting/reading equipment (to be installed in the OCC)	2
PTU connection cable	4

7.- FUNCTIONAL REQUIREMENTS OF THE SYSTEM

7.1.- INPUT/OUTPUT SIGNALS

F.1.1. The System will capture the status of direct discrete digital inputs in the cab cars. The corresponding anti-rebound filtering will be applied to these direct discrete inputs. For each discrete signal captured, there will be a mask that will make it possible to adjust the rest status of the signal so that if activated, it will always be represented by a logical 1 in memory. The acquired inputs are:

- Radio-Passengers audio connection request in Car C1
- Radio-Passengers audio connection request in Car C2
- ACH Public Announcement push button of Car C1.
- ACH Public Announcement push button of Car C2.
- ACH Cab-to-Cab audio push button of Car C1.
- ACH Cab-to-Cab audio push button of Car C2.

- ACH Cab-to-Intercom push button of Car C1.
- ACH Cab-to-Intercom push button of Car C2.
- ACH Internal Speaker Selector for Car C1.
- ACH Internal Speaker Selector for Car C2.
- ACH External Left Speaker Selector for Car C1.
- ACH External Left Speaker Selector for Car C2.
- ACH External Right Speaker Selector for Car C1.
- ACH External Right Speaker Selector for Car C2.
- Push-To-Talk button for Car C1.
- Push-To-Talk button for Car C2.Doors control
- Towed Cab-Cab audio connection request.
- Towing emergency mode.

The System will control a maximum number of direct digital inputs in each Streetcar:

C1	S1	C2
20	0	0

F.1.2. The System can activate direct discrete digital outputs in the cab cars. The physical meaning of these outputs is:

- Public Announcement connection status
- Cab-to-Cab connection status
- Cab-to-Intercom connection status
- Passenger Stop Request activation light.

These outputs will be directed to both cabs.

The System will control a maximum number of direct digital outputs in each Streetcar:

C1	S1	C2
8	0	0

F.1.3. The System will have direct analogue inputs. The meaning of these inputs is:

- Audio input from the Cab Driver Microphone of Car C1.
- Audio input from the Cab Driver Microphone of Car C2.
- Audio input from the Covert Microphone of Car C1.
- Audio input from the Covert Microphone of Car C2.
- Audio input from the Radio of Car C1
- Audio input from the Radio of Car C2.
- Audio from the Audio Train Line.

F.1.4. The System will have direct analogue outputs. The meaning of these outputs can be:

- Audio output controlling half of the streetcar's internal speakers (x2)
- Audio output for the Right platform speakers.
- Audio output for the Left platform speakers.
- Audio output to the |Cab speakers of Car C1.
- Audio output to the Cab speakers of Car C2.
- Audio output to the Audio Train Line.

7.2.- COMMUNICATIONS

7.2.1.- MVB COMMUNICATIONS

F.2.1. The System will be capable of exchanging data via serial connection with other systems through the MVB bus.

F.2.2. The System will provide the following MVB interfaces in each Streetcar:

C1	S1	C2
1	0	0

F.2.3. The data to be exchanged over the MVB ports is defined in other document.

7.2.2.- ETHERNET COMMUNICATIONS

F.2.4. The System will provide Ethernet connection to the train's network for other devices, i.e.:

- TCMS.
- others.

F.2.5. The System will provide the following Ethernet interfaces in each Streetcar (these numbers include the ports used for the network's backbone and for Sepsa's own devices):

C1	S1	C2
25	24	24

F.2.6. The data to be exchanged through the Ethernet generated by the System will include all the internal information needed by it in order to work properly (including internal state, audio, video) and maintenance data (status monitoring, configuration update and recorded data download).

F.2.7. The Ethernet network shall be provided in each car, according to the IEEE 802.3 standard, TCP/IP level connection for the different on board auxiliary equipments. All the auxiliary equipments connected to the network will have to comply with Sepsa's network requirements, as defined in : (link to actual network specification doc)

F.2.8. The system shall implement a service of dynamic addressing for all equipments and cards connected to the Ethernet network (DHCP) and also a domain name service (DNS). The addressing scheme for both Sepsa's and auxiliary equipment will be based on Sepsa's own addressing scheme as defined in : (link to actual network specification doc)

F.2.9. The system will manage a V-LAN network for maintenance, monitoring and data-exchange with the remaining on-board equipment

F.2.10. Even in the case of non-managed switches to connect equipment for maintenance purposes, there should be a mechanism to assign automatic IP address (same IP address to same device type). DHCP option 224 is proposed by CAF as the mechanism to be implemented.

F.2.11. The distribution of the band width between both networks (integrated and maintenance) will be determined in project phase,

F.2.12. The Ethernet network shall support the multicast (IGMP2) communications.

F.2.13. The Ethernet network will implement its diagnosis and monitoring.

7.3.- HUMAN-MACHINE INTERFACE

F.3.1. The System will support a Man-Machine Interface to carry out the different functions supported by the System.

F.3.2. The System Man-Machine Interface for the driver will be:

- Audio Control Head ACH digital inputs
- Rear View Monitors RVM.
- TCMS input data received through the MVB bus.

F.3.3. The following operations will be possible through the ACH:

- Establishment of public address connections:

  Public Announcement

  Cab – Int

  Cab – Cab

The functions that can be carried out for each connection will be explained in their specific sections.

- Select the destination speakers of a Cab – Passenger audio connection with the possible options :Internal speakers, Left External Speakers, Right External Speakers, all active at the same time or any combination of those.
- Display of the currently established audio connection, of those initiated by the ACH

F.3.4. The system will listen to input commands and variables published by the TCMS on the MVB bus, in order to allow the following actions to be performed:

- Select the train run number in order to display it on the External Front and Side Indicators.
- Select the destination of the train in order to inform to the automatic station announcer and to display it on the External Front and Side Indicators.
- Select pre-recorded special messages, related with the service, to be displayed on the signs and broadcasted by the PA system.
- To control the automatic announcer : select starting position along the routeskip announcement of next station..
- To adjust the audio level in the cab speaker.
- To select the camera images to be displayed on the RVM and the mode to display them (full screen, ½ split).

F.3.5. . The following status information will be published by the System in order for the TCMS to provide feedback to the driver:

- Currently loaded route number.
- Currently active audio connection.

- Special message currently being played.
- Text currently shown in the external and side displays.
- Code of the next station to be announced.
- Code of the last station announced.
- Code of destination.
- Code of the route opposite to the current one.
- Main software version of the System's devices
- Working status of the System's devices.

F.3.6. The PIS will make available static configuration data needed by the TCMS in order to provide to the driver a visual description of the stations, routes and messages. The TCMS will download the relevant configuration files through the Ethernet connection, using the FTP protocol, with the Control Unit acting as a server. Full interface specification of the format and procedure is described in the TCMS-PIS interface document.

F.3.7. The complete interface between the PIS and the TCMS is fully defined in the TCMS-PIS interface document and the MVB variable list.

F.3.8. The Rear View Monitor will be the HMI between the driver and the side rear view cameras.

F.3.9. The System will display on the RVM the images of the side rear view cameras of the Streetcar. The image shall be mirrored to simulate the image seen on side mounted mirrors.

F.3.10. The System will display on the RVM the images of the cameras selected in the Cab Terminal of the TCMS.

F.3.11. The System Human-Machine Interface for the System Startup and Maintenance staff will be done through:

- LEDs in the Control Units.
- PTU laptop.

F.3.12. The following actions can be done using the PTU:

- Viewing the System's operating status.
- Viewing internal System errors.
- System Monitoring.
- Live images visualization.
- Stored images downloading and visualization.
- Load configurations

- Download Recorder´s stored data.

The following sections describe each one of the functions in detail.

7.4.- MONITORING

F.4.1. The System will allow the monitoring of the internal status of the System using the following methods:

- LEDs of the Control Units.
- PTU laptop.

Each one of these will allow a different level of monitoring.

F.4.2. The LED indicators will display the operational status of the System. Their main function is to indicate whether the System is fully operational or has some type of fault:

- Equipment power supply status.
- Self-check result.
- Communications errors.
- Unit not configured.

F.4.3. The PTU will be the most complete monitoring tool that allows the highest level of monitoring. It can be used to display the:

- SW versions of the programs running on the Units.
- System's operational/fault status.
- Value of the configured parameters.
- Allowable values of the configurable parameters.
- Date and time of the internal clock.
- Communications status of each one of System's devices in the unit.
- Self-check results.

7.5.- CONFIGURATION

F.5.1. The System will allow the configuration of the internal status of the System with the PTU laptop.

F.5.2. The following actions can be done with the PTU:

- Configure the Serial Number on which the Equipment is installed.

- Change the access password.
- Configure functional parameters.
- Upload of Station Announcer Data Base.

F.5.3. All of the system configuration operations will be protected by a password, which may be modified.

7.6.- CHRONOLOGICAL FAULT AND DATA RECORDER

F.6.1. The System will keep an internal Fault and Data Recorder where it will record information regarding the System.

F.6.2. The Recorder will be kept in the System's Control Units.

F.6.3. The Recorder will store the data in non-volatile memory, allowing it to be maintained if the Unit's power supply fails.

F.6.4. The Recorder will store the data in a memory buffer with a data ring structure, overwriting the oldest information what the maximum size is reached.

F.6.5. The Recorder will be based on recording by events (faults), which may include:

- Communication errors with one of the System's Units.
- Errors in communications with other systems, MVB communication, Ethernet.
- Date/time changes.

F.6.6. All faults shall be date and time stamped (from the master clock), in an approved chronological order (last in, first out).

F.6.7. This data shall be accessible on the system, using the PTU.

F.6.8. Once configured using the PTU, the data logger shall not require the use of the PTU except for retrieval and viewing of logged data.

F.6.9. The System will allow the Recorder´s stored data to be downloaded over the local Ethernet connection.

F.6.10. The data downloaded from the Recorder will be visualized using the PTU/Maintenance laptop.

F.6.11. The recorded data will be downloaded as an xml file, and can be shown in the PTU or any other laptop.

F.6.12. A complete description of the recorded data and faults is provided in the document (link to log document).

7.7.- PUBLIC ADDRESS AND INTERCOM SYSTEM

F.7.1. The PIS audio connections are done manually through the ACH,automatically from the station , though MVB input coming from the TCMS or though the monitored digital inputs.

F.7.2. The System will be able to establish the following connections:

- Cab-to-Passengers (PA).
- Radio-to-Passengers.
- Cab-to/from-INT.
- Cab-to/from-Cab.
- Door control to Passengers.
- Pre-recorded messages-to-Passengers.
- Automatic announcement system-to-Passengers.
- Passenger Stop Request

F.7.3. The System allows the establishment of any public address connection pressing at most two buttons, unless a different selection of speakers from the currently selected one is desired. The active public address connection, among those selected by the driver on the ACH, at any time will be indicated to the driver through the ACH indicators.

F.7.4.

The following section describes the different possible connections:

7.7.3.- CAB-TO/FROM-CAB COMMUNICATION

F.7.5. The System allows two ways half-duplex audio communication between any two driving cabs of the train, either in the same unit of between two units in emergency towing mode

F.7.6. The train operator will push the "CAB-to-CAB" push button of the ACH of any cab in order to establish a Cab – Cab audio connection. When the button is pressed, the CU installed in the same car will energize the train line "TOWED CAB-CAB ORDER" to inform to a possible towed train unit that a Cab-Cab audio connection is demanding.

F.7.7. When the Cab-Cab connection is established from a cab, an indicator will sound on the Cab Speaker and a visual indicator will appear on the ACH so that the train personnel will be aware that the connection is being requested.

F.7.8. The train driver shall respond to the call by pressing the "CAB-to-CAB" push button (momentary), permitting the calling cab to be heard on the cab PA loudspeaker and using the push-to-talk (PTT) switch to talk to the operator on the calling cab.

F.7.9. The Cab – Cab connection will be released pressing "CAB-to-CAB" push button again, in any of the cab where the connection is established

7.7.4.- **CAB-TO-PASSENGERS COMMUNICATION**

F.7.10. The System will allow one-way audio communication between any of the driving cabs and the passengers over the train's loudspeakers.

F.7.11. The audio connection will be directed to the selection of speakers configured at the time the connection was requested, and will stay the same for the whole duration of the connection.

F.7.12. The train operator will push the "PA" push button (momentary) of the ACH of the driving cab in order to establish a Cab to Passengers audio connection.

F.7.13. When the Cab-Passenger connection is established, an indicator (bell) will sound on the train's internal loudspeakers for the passengers and a visual indicator will appear on the ACH.

F.7.14. The Cab-Passenger connection will be released pressing "PA" push button again.

F.7.15. The Cab-Passenger connection will be enabled only in the active cab.

7.7.5.- **RADIO-TO-PASSENGERS COMMUNICATION**

F.7.16. The System will allow the transmission (automatic or at the driver's discretion) to passengers of the train-ground audio signal.

F.7.17. The Control Unit will have an analog input for radio audio and a digital input for the Radio/driver's notification that the audio must be broadcasted to the passengers.

F.7.18. The audio connection will always be directed to all of the internal, external left, and external right speakers. Manual speaker selectors won't affect this connection.

7.7.6.- **DOOR ACTIVATION WARNING AUDIO CONNECTION**

F.7.19. The System will allow the transmission to passengers of the door control audio signal.

F.7.20. The Automatic Station Announcer of the System will generate the door audio signal in function of a digital variable received from the TCMS by serial data communication or in function of the discrete input of the Control Unit connected to the door control equipment.The audio connection will always be directed to all of the internal, external left, and external right speakers. Manual speaker selectors won't influence this connection.

F.7.21. The Door activation warning audio connection will always be directed to all of the internal, external left, and external right speakers. Manual speaker selectors won't affect this connection.

F.7.22.

7.7.7.- **CAB TO/FROM INTERCOMS COMMUNICATIONS**

F.7.23. The System will allow two ways half-duplex audio communication between a driving cab and one of the train's emergency intercoms INT.

F.7.24. The INT station shall incorporate a "press-to-latch" feature enabling immediate communication with the train operator via the paging loudspeaker without having to continue to press the call button.

F.7.25. When the call button is pressed, the INT function shall be annunciated in the controlling cab and at the INT station by means of a distinctive phone ring tone and a cab and INT station indicating light.

F.7.26. If additional INT stations are activated, the calls after the first shall be placed in a queue. Queued INT stations shall be annunciated by a busy tone over the cab speaker and by visual indication in the cab.

F.7.27. After the operator cancels the first INT request an audible ring tone shall be heard over the cab speaker to indicate another INT call.

F.7.28. The train operator shall respond to the call(s) by pressing the "INT" pushbutton (momentary), permitting the first station to be heard on the cab PA loudspeaker and using the push-to-talk (PTT) switch to talk to the passenger.

F.7.29. Pressing the "INT" push button again shall cause the connected station to be disconnected and the next station in the queue to be connected.

F.7.30. Selecting another PA function shall cause the connected station to be placed on hold and permit the selected mode to be used, after which the train operator shall be able to return to the INT mode and select the on-hold station or the remaining stations in the queue.

F.7.31. When the last station in the queue has been served, pressing the “INT” button, or selecting another PA mode, shall cause the intercom indicating light to turn off.

F.7.32. Cab speaker volume for the ring tone and conversation shall be adjustable using PTU software and from the Cab Terminal of the TCMS. It will not be possible to set the audio level of the cab speaker to zero.

F.7.33. The train operator will be able to answer to any Intercom call only in the active cab.

7.7.8.- **PASSENGER STOP REQUEST**

F.7.34. The system will receive the activation status of the Passenger Stop request though the MVB bus.

F.7.35. Activating the passenger stop request anywhere in the vehicle shall sound the local stop request chime only in the passenger area of the vehicle, and shall sound an audible alert for 0.5 seconds in the operator’s cab.

F.7.36. The system will activate a digital output corresponding to the activation of the Passenger Request Stop light. Once activated, the cab stop request light shall remain illuminated and the cab audible alert shall latch off, until the doors have been cycled.

7.7.9.- **MANAGEMENT OF PUBLIC ADDRESS PRIORITIES**

F.7.37. The System will manage all of the public address connections through a priorities mechanism.

F.7.38. Any connection may be interrupted by a higher-priority connection, unless the two connections do not share resources (speakers, microphone, etc.).

F.7.39. Audio connections priorities are defined in the following table:

Connection	**Priority**
Cab-to-passengers	Highest
Radio-to-passengers	
Door control-to-passengers	
Cab-to/from INT	
Cab-to/from-Cab	
Pre-recorded messages-to-passengers	
Automatic announcement system-to-passengers	Lowest

F.7.40. The final design of priorities will be decided during project phase and validated by CAF. The priorities final order will be revised and updated in a later revision of the document. Once the final order of priorities is agreed, all of the possible cases and the behavior of the system when multiple audio connections are active at the same time will be described in a design document, which will be submitted to CAF for approval.

F.7.41. When the System is started, there will be no audio connection activated by default.

7.8.- PRE-RECORDED MESSAGES

F.8.1. The system will be able to store audio, text and mixed pre-recorded messages.

F.8.2. The System will provide a memory of 800MBytes for audio, text and mixed storage, enough for more than 2000 total messages.

The System has the actual following limitations :

- Maximum number of characters for text message 1000.
- Maximum number of routes that can be defined : 999.

• Maximum number of manual special messages : 199

F.8.3. Pre-recorded messages could be audio or visual. The Customer will provide the audio files (MP3 format 32 KHz, 64 Kbps and bit reservoir disabled) and the text messages of any length with previously mentioned memory capacity of 16kB.

F.8.4. The system will provide up to 800 MBytes to store the pre-recorded audio or text files.

F.8.5. For each message, it could be selected if there is an acoustic and/or visual broadcast. This selection will be carried out with maintenance tools.

F.8.6. The driver will launch the message from the TCMS's MMI and it will be automatically played or displayed according the message configuration.

F.8.7. Pre-recorded messages with audio content will be played in the car speakers. Speaker selection in the ACH won't affect this audio connection.

F.8.8. Pre-recorded messages with visual content can be defined to be displayed in the External Indicators and/or the Internal Display using the supplied configuration tool.

F.8.9. The customer will provide message codes together with audio and text data for the initial configuration.

7.9.- AUTOMATIC ANNOUNCEMENT SYSTEM

F.9.1. The Automatic Announcement System, or Station Announcer, will send to the passengers the audio and visual information regarding the train's route and train run number.

F.9.2. For each route, it will be possible to define the acoustic and visual announcements, according the geographical position along the route or the data received from the TCMS system, on the following devices:

- External Front Indicator (visual announcement).
- External Side Indicator (visual announcement).
- Internal Display (visual announcement).
- Public address system (acoustic announcement).

F.9.3. The broadcasted information will be:

- Next station.

- Train destination.
- Special messages associated with each station.
- Special notifications.

F.9.5. The Station Announcer will require the following data from either the MVB connection with the TCMS or digital inputs, where applicable, in order to work correctly:

- Active cab
- Doors open/closed state
- Travelled distance counter
- Route number, selected by the driver

F.9.6. The Customer shall provide the required information to build the automatic announcement system database:

- Station names.
- GPS location of the stations.
- Relative distance of the stations along the route.
- Template of the desired announcement sequence for any given route.
- Route and station codes.

F.9.7. To determine its position on the train's route, the System will use GPS location data and/or TCMS travelled distance information, which will be received from GPS and/or TCMS systems through MVB data communications.

F.9.8. All the triggers will be based on the relative travelled distance along the route. This will be calculated internally by the Announcer, using the distance counter and GPS data.

F.9.9. The System will allow the selection of a minimum of 99 routes, including possible reverse-running routes.

F.9.10. The System shall allow audio and text messages to be stored digitally along with information identifying the conditions under which the message is to be broadcast. The memory shall have the capacity for at least 999 routes, with a minimum of 100 stations for each route, 10 audio, and 10 text messages per station, and no less than 199 special messages, audio and text. Storage for audio messages shall assume at least 30 seconds per message. Text messages shall assume 1000 characters each.

F.9.11. Message capacity shall depend only on available memory. The longest message that can be played is 1000 characters.

F.9.12. The system shall function automatically, after the operator has entered the starting location and destination via the block and route number inputs into the TCMS's MMI.

F.9.13. When the route has been completed, the driver will have to select the inverse to the current one, for the return trip. The PIS will publish the code for the inverse route through the MVB bus.

F.9.14. In normal operation the Automatic Announcement system shall track the progress of the train through the system and make station and other informational announcements as described herein. The system shall make a train location determination based on stopping at and leaving stations, and information provided by the TCMS and/or GPS system.

F.9.15. As the train leaves each station, the system shall be automatically set for the next station.

F.9.16. The system shall provide for multi-lingual announcements. Multi-lingual announcements shall be automatically produced by the pre-programmed selection of multiple, separate announcements.

F.9.17. The Announcer will contain the station tables and their location on the line for each one of the lines over which the train travels. These tables will include the markers where the next stop and/or other message announcements have to be generated.

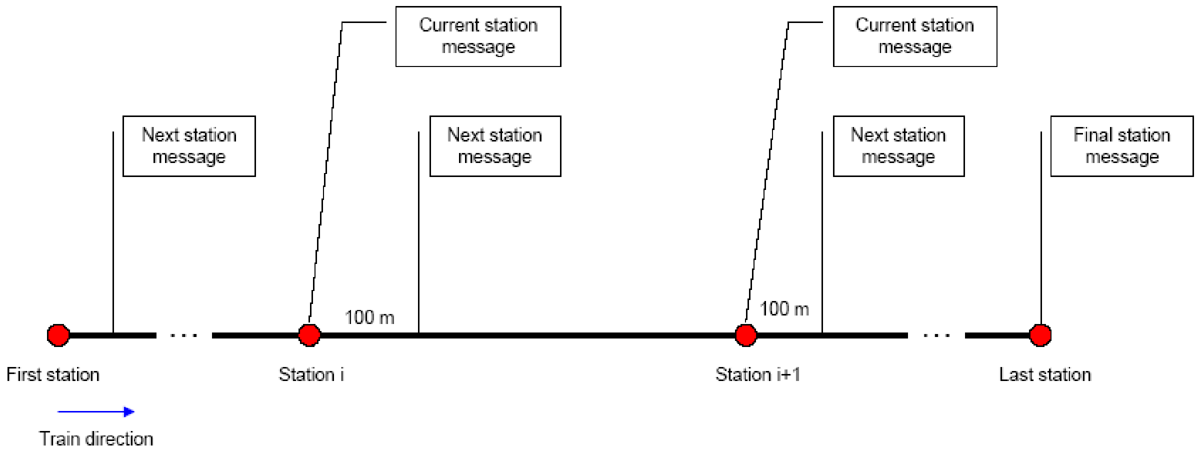


Figure 3 Example of station announcement diagram

F.9.18. The Announcer will also allow the broadcast of other messages associated with the specific stations, such as: transfer connections, rate area limits, others messages.

F.9.19. The Announcer will allow the driver to manually skip the next station on the route, to position the train in a starting station along the route different from the predefined one, and to load the route opposite to the currently loaded one. All these commands will be relayed to the announcer though the MVB interface.

F.9.20. The complete interface between PIS and TCMS, will be defined in a design document agreed between Sepsa and CAF.

F.9.21. The System will automatically control the volume of the messages for passengers according to the general noise level in the car (one level). The announcer will receive the noise level value though the MVB bus.

F.9.22. The System will automatically control the volume of the messages for passengers according the train speed (two levels). The announcer will receive the speed value though the MVB bus.

F.9.23. The System will automatically control the volume of the messages for passengers according the car occupation (two levels). The announcer will receive the car occupation value though the MVB bus.

F.9.24. The system should permit the definition of events based on location/odometry. These events will be sent via the MVB bus when the location defined for each event has been reached.

7.10.- EXTERNAL FRONT INDICATOR

F.10.1. The External Front Indicator main function is to show the route number and the train destination.

F.10.2. The train Operator will select the route and destination on the control panel of the TCMS system which will send it to the IRISD System. The System will send the destination to all the External Indicators of the train.

F.10.3. The IRISD System will send back to the TCMS system the same messages sent to the External Indicators though the MVB bus.

7.11.- INTERNAL DISPLAY

F.11.1. The Internal Display main function is to display useful information for the passengers.

F.11.2. Each ID shall display static 12character text messages. It will be possible to show any text either as fixed (if less or equal than 12 characters) or scrolling horizontally. This can be defined using the supplied configuration tool.

F.11.3. By default, if a text is configured to be shown as static text and it exceeds the maximum of 12 characters, it will be shown scrolling horizontally.

F.11.4. The ID will be able to show the following information:

- Train destination.
- Next stop.
- Text message associated with the station.
- Special text messages related with the service.
- Other information like: date, time, temperature, etc.

F.11.5. The ID will be able to show the text messages related to the special acoustic announcements.

F.11.6. Between two route stations, the ID will show the next stop station name.

F.11.7. Each ID shall display the name of the station as the train enters a station and during the train stop.

F.11.8. In the final station, the ID will show the current station name until the driver carries out a route inversion.

7.12.- EXTERNAL SIDE INDICATOR

F.12.1. The External Side Indicator main function is to display the route number and the train destination.

F.12.2. The train Operator will select the route and destination on the control panel of the TCMS system which will send it to the IRISD System. The System will send the destination to all the ESI of the train unit.

7.13.- VIDEO RECORDING

F.13.1. The images received from the cameras installed in the train will be transmitted to the Control Unit over Ethernet.

F.13.2. The images will be transmitted and the information will be exchanged between the different Video Units in digital format over an Ethernet backbone network with IP protocols.

F.13.3. The System will provide the capacity for recording continuously the images of 14 cameras (what includes two spare ones) at 30 fps and 1280x1024 resolution for a minimum of 72 hours.

F.13.4. The System will attach the following information to the recorded images:

- Date
- Time
- Car identification.
- Camera identification.

F.13.5. The System will provide 2000 GB of memory for recording the images. This memory size includes the memory reserved for alarm video (protected memory) and will provide a recording time of 72 hours.

F.13.6. The compression algorithm for recording and transmitting images will be H.264.

F.13.7. The recording in normal mode will be in a ring, so that once the memory is full, the recording will continue over the oldest images.

F.13.8. The recordings in alarm mode will be protected so that they are not deleted when later recordings are made.

F.13.9. These recordings may only be deleted by authorized personnel using the PTU laptop or after 30 days or programmed time.

F.13.10. For each event, the system will record all the cameras installed in the car where the alarm has been activated and the active Cab Covert Microphones audio.

F.13.11. The System will generate an alarm that will be sent to the TCMS when this protected storage zone reaches the established level of full disk capacity.

F.13.12. The System will detect any lack of video signal of any camera and will inform to the driver through the TCMS.

F.13.13. The recordings on the removable hard disk will always be protected with watermarks or a similar procedure, which will make it possible to detect manipulation.

F.13.14. The recorded data will be only accessed by authorized personnel with the correct access password. The application will have two levels of security. The access capacity for each level will be defined in the project phase.

F.13.15. The System will send to the TCMS information about its status, for example:

- Auto-test in progress.
- Unit not configured.
- Power supply OK.

- Recording status ON/OFF.
- Hardware and software product versions and names
- Recorder error (specifying which one).

F.13.16. In case of a failure in the train's power supply, the System will reboot and begin recording automatically once the power has been restored and the internal tests have been completed.

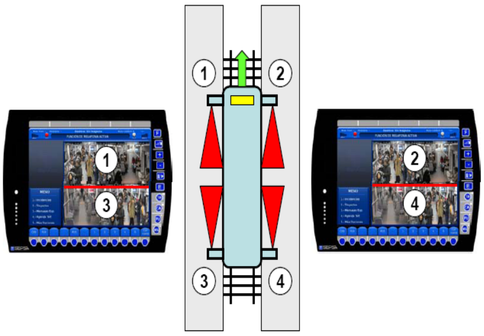
7.14.- IMAGES VISUALIZATION

F.14.1. The side rear-view cameras live images will be displayed on the Rear View Monitors screens. The image shall be mirrored to simulate the image seen on side mounted mirrors.

F.14.2. There will be two RVM, one on each side of the console of the driving cab. Each RVM monitor will display the live images of the side rear view cameras of the same side of its installation.

F.14.3. It will be possible to view the recorded images using the PTU/Maintenance PC.

F.14.4. In a single TU configuration, the RVM will display the rear-view cameras with the following format:



Note: Yellow rectangle means the active cab.
Green arrow identifies the train direction.

Figure 4 Single TU configuration (rear view cameras)

7.15.- REDUNDANCY

The System will provide different redundancy functionalities which improve the reliability of the System.

F.15.1. The Control Unit has redundant Audio Amplifier. Each one of the two Amplifiers powers half of the internal speakers so that a simple fault in the Amplifier module only results in audio loss in half of the speakers of the streetcar.

F.15.2. Each Ethernet connection between the Control Unit and the Switch Ethernet Modules of the System will be made with twisted-pair wire to improve the reliability of the Ethernet connections, being these two operative cables in all moment (according to the 803.3 standard ad link aggregation), and the communication of data can use any one of the two, getting the double band width. In case in that a connection breaks up, the other follows working without disturbances and without damages for the System.

7.16.- ADDICIONAL REQUIREMENTS

F.16.1. The System will be equipped with the means necessary to keep it from locking up due to program faults (watchdog).

7.17.- CCTV'S HD OFF LINE VIDEO EXTRACTING/READING

The System will provide a tool for extracting/reading the stored video images of CCTV from a HD removed from the CCTV Control Unit. This tool will permit also to view and analyze the downloaded images.

F.17.1. The System will provide the necessary hardware to connect a HD removed from a DVR to a PC: Maintenance Console of the OCC, a Maintenance PC or PTU PC.

F.17.2. The System will provide the SW to be installed in the PC in order to permit to download the CCTV stored images from the HD connected to the PC.

F.17.3. The downloaded images will be stored in the HD of the PC.

F.17.4. The provided SW will permit to view the downloaded images, stored in the HD of the PC, on the screen of the PC.

F.17.5. The SW will provide the following functions:

- Visualize the HDE´s stored videos,
- Visualize of the images recorded in the own command position,
- Visualize frame by frame, in normal or fast speed,
- Store the images in formats open to the public,
- Record the images in DVD for sending it to police or competent institution.
- Etc.

Figure 5 Example of CCTV images view and analysis tool.

7.18.- STATION ANNOUNCER DATA BASE EDITOR

The System will provide a tool for editing the routes, stations, messages, etc to be handled by the Automatic Station Announcer.

F.18.1. This Editor will permit setting the data base of the stations announcer for the automatic announcer and creating the events related to a route, including:

- Lines and Routes database.
- Station names database (text and audio files).
- Definition of the messages (text and associated audio file) to be broadcasted along each route.
- Definition of the GPS locations or TCMS events at which the messages must be broadcasted.
- Other Lines and passenger transportation services connections available in each station.
- Definition of special messages (text and associated audio file).

F.18.2. The Editor will also provide the upload and modification of previously edited configuration data base.

F.18.3. The Station Announcer Configuration Editor will let to the staff to control of the versions of the different configuration data generated.

F.18.4. The Editor tool will produce a station announcer configuration date base in the format used by onboard PIS station announcer.

F.18.5. The Station Announcer Configuration Editor runs in Windows and is based on Graphic Windows Menu. See next figures as examples.

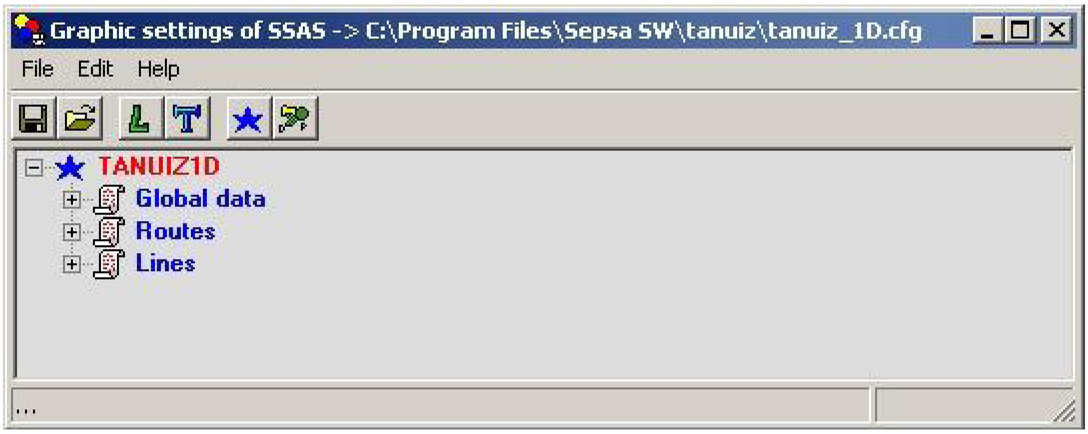


Figure 6 Main Windows with a configuration opened.

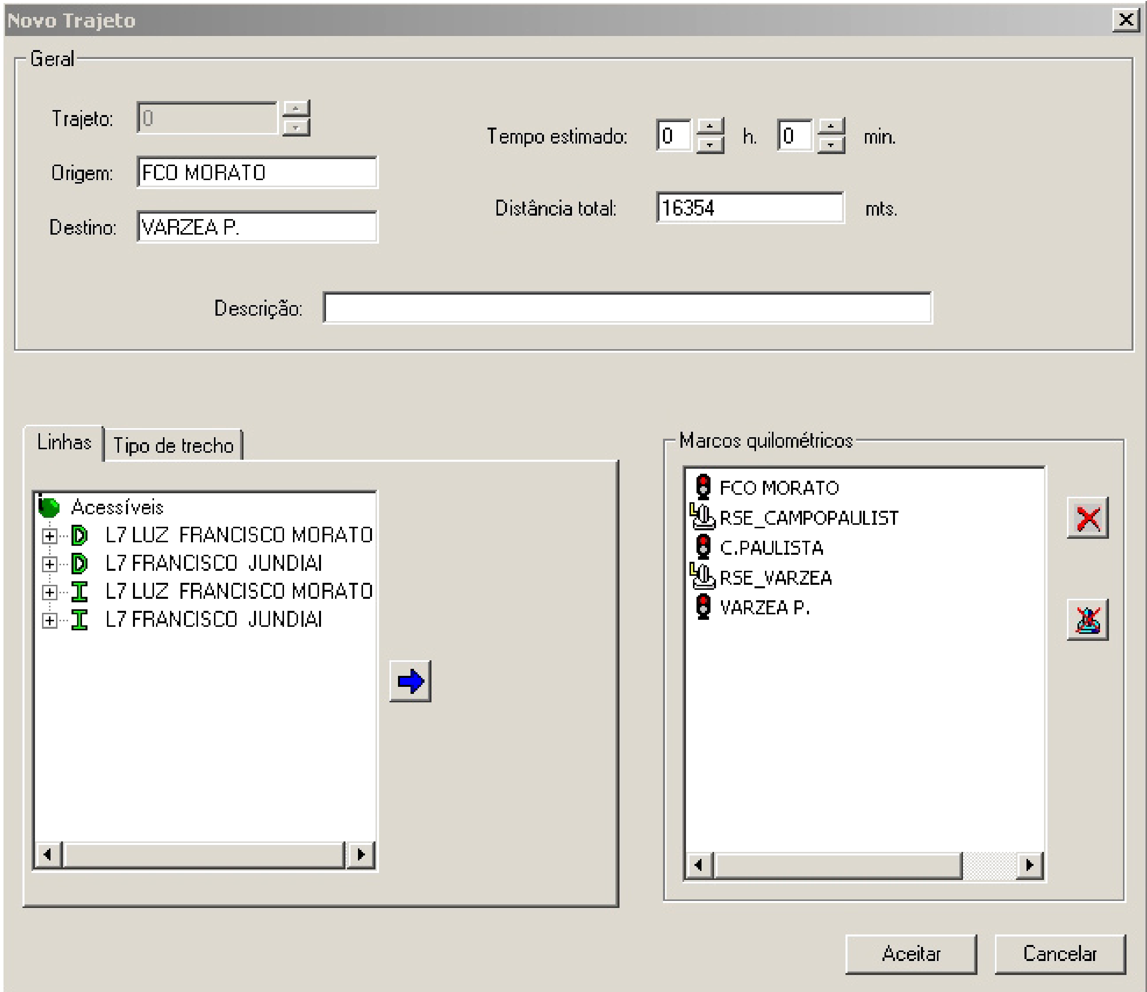


Figure 7 Example of route definition.

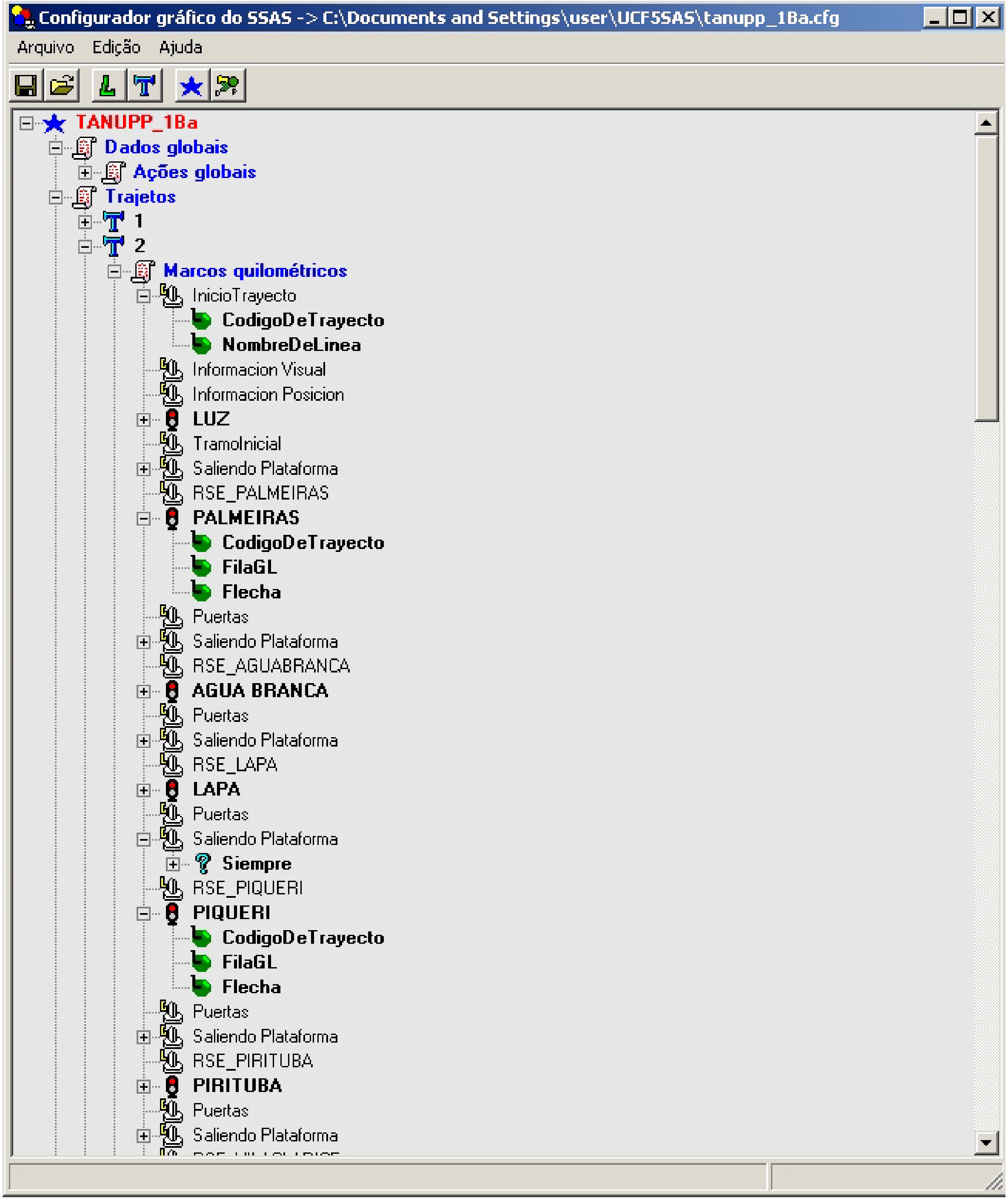


Figure 8 Example of route definition.

F.18.6. SW licenses to be installed in a PC will be provided.

7.19.- PORTABLE TEST UNIT

F.19.1. The Portable Test Unit laptop will be use to download video contents, to visualize/extract files, System configuration, System monitoring and diagnosis, etc. It consists of a laptop with an Ethernet port and maintenance SW.

F.19.2. The PTU laptop will provide the following maintenance functions:

- Configure the serial number on which the equipment is installed.
- Check installed SW versions.
- Change the access password.
- Check configuration files versions.
- Monitoring of System operational status.
- Set System parameters values.
- Check System parameters ranges.
- Check System operational/faults status.
- Monitoring of RTC date and time values.
- Monitoring of discrete inputs status.
- Monitoring of discrete outputs status.
- Updating the configuration and the firmware of the System.
- Communications status of each one of the units.
- Check the self-test results.
- Download the internal event recorder stored data.

F.19.3. The PTU laptop will provide the following functions related to the specific passenger information functionality:

- Edit audio levels (volume) for each audio connection.
- Monitoring of public address connections.
- Load audio and text files.

F.19.4. The PTU laptop will provide the following functions related to the specific CCTV functionality:

- Display video of the cameras in real time.
- Visualize the HDE´s stored videos,
- Download the images recorded.
- Delete the images recorded in the Hard disk of the CU.
- Visualize of the images recorded in the own command position,

- Visualize frame by frame, in normal or fast speed,
- Store the images in formats open to the public,
- Record the images in DVD for sending it to police or competent institution.
- Updating the configuration and the firmware of the System.

F.19.5. Application SW licenses to be installed in a laptop will be provided. The laptop is not in the scope of supply of the System.

7.20.- AUDIO CAPTURE AND ENCODING

The System will provide a tool for capturing audio, convert it to digital format and encode it in a compatible format (MP3) to be handled by the Automatic Station Announcer.

F.20.1. The System will provide a PC Audio Capturing Card (SoundBlaster or similar) and a Microphone to be installed in the Maintenance Console of the OCC.

F.20.2. The System will provide the corresponding SW for audio capturing, digitalization and encoding.

F.20.3. The capture audio will be stored in the hard disk of the Maintenance Console for use it in the data base of the Station Announcer.

8.- TECHNICAL REQUIREMENTS OF THE SYSTEM

8.1.- GENERAL TECHNICAL REQUIREMENTS

T.1.1. The equipment of the System will be supplied by the battery nominal voltage of 24Vdc with an operating range of 16,8Vdc to 30Vdc.

T.1.2. The operating temperature for all of the system’s equipment will be as specified in category TX of the standard EN 50155, except: Cameras and its Housing (from -20ºC to +50ºC), TFT screens of the Rear View Monitors (from -30ºC to +70ºC), Hard Disks (from 0ºC to +50ºC) and CCTV CPU (from -20ºC to +70ºC).

T.1.3. The level of protection of the enclosures of the equipment installed in cabs will be IP20.

T.1.4. The level of protection of equipment installed in the passenger compartment (intercoms, speakers, etc.) will be IP40.

T.1.5. The dielectric rigidity of the systems will withstand 1000Vef 50Hz for 1 minute applied between the chassis and the connector terminals according to EN 50155.

T.1.6. The separation between racks in the cabinets of the train unit must be sufficient to allow air to circulate between them.

T.1.7. The equipment will withstand vibration in accordance with the standard IEC 61373 Category 1, Class B.

T.1.8. The shock resistance of the equipment will comply with the limits in the standard IEC 61373 Category 1, Class B.

T.1.9. The level of insulation between the chassis and the terminals of the equipment connectors will be greater than 20MΩ at 500VDC, as specified in the standard EN 50155.

T.1.10. All equipment will comply with the EMC requirements and electrical service conditions specified in section 3 of the standard EN 50155 and in accordance with the test mentioned in section 10 of the standard.

8.2.- CONTROL UNIT TECHNICAL REQUIREMENTS

T.2.1. The size of the CU equipment will allow them to be housed in cabinets for 19” racks 6U. For more details see drawing S064522.

T.2.2. The CU has a double audio amplifier, class D.

T.2.3. The bandwidth of the recorded messages will be at least, 200Hz<f<15 KHz.

T.2.4. The bandwidth of the amplifiers will be at least, 200Hz<f<15 KHz.

T.2.5. The total harmonic distortion will be less than 1% at 1 kHz.

T.2.6. The CU will have two audio power outputs (two entirely separate and functionally independent amplifiers) to power the saloon speakers in the passenger compartment.

T.2.7. The CU includes a 24-port Ethernet Switch accessible at the front outside of the Control Unit. Each of the Control Units in the IRISD system as well as any equipment with an Ethernet connection will be connected to this switch.

T.2.8. The connection of the Ethernet bus is done using M12, D codification connectors.

T.2.9. The Ethernet switch in each Control Unit will provide support to the train's Ethernet network (Ethernet Backbone) for the exchange of data, video and audio between the equipment in the same system and from different systems.

T.2.10. The CU is equipped with a digital input/output module with twenty four (x24) inputs and fourteen (x14) outputs.

T.2.11. The discrete input are "dry-contact" type. It will be equipped with a contact-cleaner circuit.

T.2.12. The contacts of the output relay will have a maximum capacity of I=0.4A at battery voltage and will be equipped with an over voltage reduction RC circuit.

T.2.13. Twenty (x20) of the digital inputs will be used for ACH interface, listed in paragraph F.1.1.

T.2.14. The ACH digital inputs will sense the close/open state of free voltage contact for the above mentioned selectors and push buttons.

T.2.15. The three (x3) digital outputs for LED indicators of the ACH, which will be common between the two cabs are listed in paragraph F.1.2.

T.2.16. The CU has a processor with 32-bit RISC architecture to control the public address and passenger information system functions.

T.2.17. The board connectors will mainly be DIN 41612. The connectors will be mechanically coded to prevent them from being plugged in incorrectly or in the wrong slot, which could damage the circuits.

T.2.18. The Control Unit will have an MVB communications port to connect to the TCMS, through which it will receive all of the information from the train and it will send monitoring and diagnostic data.

T.2.19. The redundancy of the connectors of this MVB bus and the assignment of pins will make it possible to give continuity to the bus when the unit is disconnected.

T.2.20. The CU has a processor with 32-bit RISC architecture to control the video recording functions.

T.2.21. The CU will be equipped with hard disks that can be removed. The hard disks of video recording functions will have a capacity of 2000 GB.

T.2.22. The CU will be equipped with hard disks with a capacity according to the recording and quality of image requirements.

T.2.23. The HD will be equipped with the necessary elements in order to absorb the vibrations.

8.3.- SWITCH ETHERNET MODULE TECHNICAL REQUIREMENTS

T.3.1. Each Switch Ethernet includes the next Ethernet ports accessible:

Switch Type 2: 24 Ethernet ports

T.3.2. The connection of the Ethernet bus is done using M12, D codification connectors.

T.3.3. The Switch Ethernet provides a **"Fail-safe" mode**. That is, if one of the SWE fails, the communication with the other devices in the same bus is still working.

T.3.4. The size of the Switch Ethernet equipment is shown in the drawing S064539.

8.4.- INTERCOM TECHNICAL REQUIREMENTS

T.4.1. The Intercom (INT) is equipped with one speaker, a microphone, state indicators and a button. For more details see drawing S064528.

T.4.2. The Intercom is equipped with two LED for operational state indication.

T.4.3. The Intercom has a button which activates it when pressed.

T.4.4. The button will be able to be pushed with the palm of the hand.

T.4.5. The front plate of the Intercom will be marked with engraved graphics, in English text and Braille, to identify the unit as an "Emergency Intercom" unit. The instructions shall read, "To Contact Driver Push Button Once", or approved similar language.

T.4.6. The Intercom is equipped with a voice digitizer module.

T.4.7. The Intercom is equipped with one (1) 10/100 Mbps Ethernet port and a configuration and power supply connector.

T.4.8. The equipment is connected to the Ethernet bus using circular M12 connectors.

T.4.9. The Intercom contains a software module to provide dynamic IP addressing capability.

T.4.10. The Intercom is equipped with the necessary means to automatically configure the Communications addressing in the bus, through external wiring connected locally to the aerial connector. With this function, no manual configuration/manipulation has to be done during installation on the train, replacement, etc.

8.5.- SALOON AND CAB SPEAKERS TECHNICAL REQUIREMENTS

T.5.1. The Interior Saloon Speakers include the acoustic box in which they will be installed, in addition to the impedance adaptation transformer. For more details see drawings S064525 and S064526.

T.5.2. The Interior Speaker assembly will include the possibility of selecting power to extract from the audio line to which it is connected.

T.5.3. The Cab Speaker has the same technical characteristics except it has no impedance adaptation transformer neither the selector of power to extract.

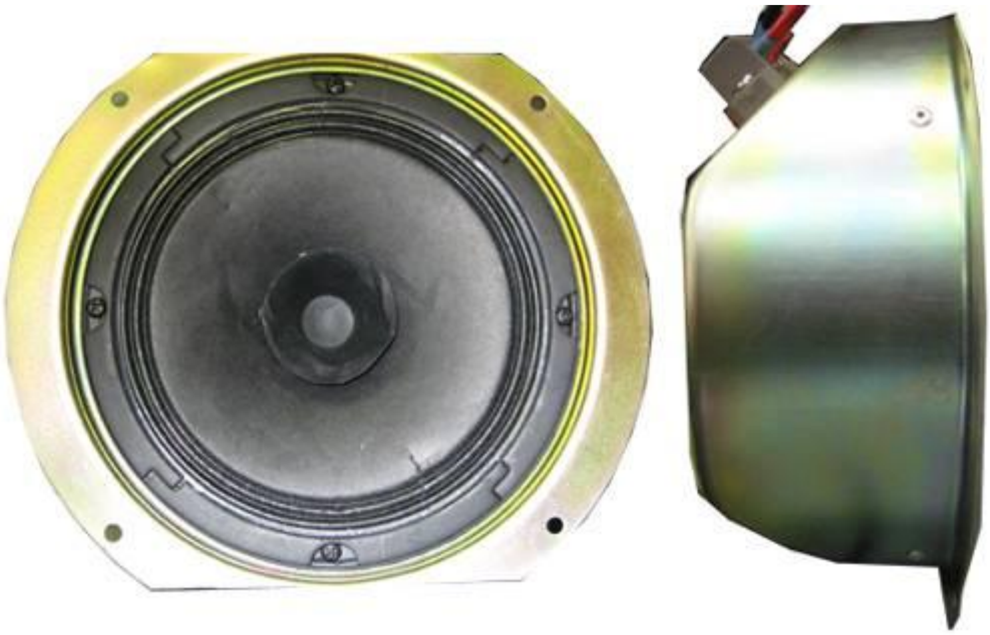


Figure 9. Example of Interior and Cab Speaker

8.6.- EXTERNAL SPEAKERS TECHNICAL REQUIREMENTS

T.6.1. The Speakers include the acoustic box in which they will be installed, in addition to the impedance adaptation transformer. For more details see drawing S064527.

Figure 10 Example of an Internal Display

F.6.2.

T.6.2. The Speaker assembly will include the possibility of selecting power to extract from the audio line to which it is connected. The power delivered to the loudspeaker from the transformer shall be transformer tap adjustable to 0.9, 1.8, 3.8, 7.5 or 15 W.

8.7.- INTERNAL DISPLAY TECHNICAL REQUIREMENTS

T.7.1. The Internal Display ID is equipped with a matrix of 12x96 amber LEDs.

T.7.2. The ID will display 13 characters for door opening side indication all of them 75mm high. Each character will have a resolution of 12x6 LEDs with a stroke width of 1 LED and 1 space (LED) between characters.

T.7.3. For more dimensional details see drawingS064529 S064529.

T.7.4. The ID is equipped with one (1) 10/100 Mbps Ethernet port and a configuration connector. The display is connected to the control unit by an Ethernet bus (data information is exchanged on this bus).

T.7.5. The equipment is connected to the Ethernet bus using circular M12 connectors.

T.7.6. The ID contains a software module to provide dynamic IP addressing capability.

T.7.7. The ID is equipped with the necessary means to automatically configure the communications addressing in the bus, through external wiring connected locally to the aerial connector.

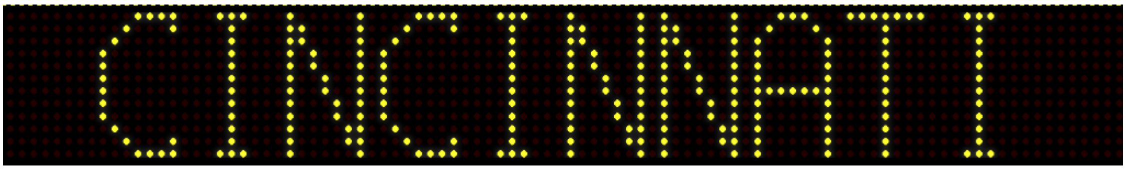


Figure 11 Example of an Internal Display

8.8.- EXTERNAL FRONT INDICATOR TECHNICAL REQUIREMENTS

T.8.1. The External Front Indicator (EFI) will be equipped with a matrix of 12x150 amber LEDs.

Figure 12 Example of an External Display

T.8.2. The EFI will display three (x3) numbers plus twelve (x12) characters 125mm high. Each character will have a resolution of 12x8 LEDs with a stroke width of 2 LEDs and 2 spaces (LEDs) between characters.

T.8.3. The EFI is equipped with one (1) 10/100 Mbps Ethernet port and a configuration connector. The EFI is connected to the control unit by an Ethernet bus (data information is exchanged on this bus).

T.8.4. The equipment is connected to the Ethernet bus using circular M12 connectors.

T.8.5. The sign contains a software module to provide dynamic IP addressing capability.

T.8.6. The signs are equipped with the necessary means to automatically configure the Communications addressing in the bus, through external wiring connected locally to the aerial connector.

T.8.7. For more details see drawing S064530.

8.9.- EXTERNAL SIDE INDICATOR TECHNICAL REQUIREMENTS

T.9.1. The External Side Indicator (ESI) has the same technical characteristics than the External Front Indicator.

8.10.- CAMERAS TECHNICAL SPECIFICATIONS

8.10.1.- REAR VIEW CAMERA TECHNICAL SPECIFICATIONS

T.10.1. The Rear View Camera selected is VIVOTEK MD8562D. Technical specifications are available from manufacturer datasheet.

8.10.2.- INTERNAL CAMERA TECHNICAL SPECIFICATION

T.10.2. The Internal Camera Technical Specifications is the same ones than those of the Rear View Camera. VIVOTEK MD8562D.

8.10.3.- FORWARD FACING CAMERA TECHNICAL SPECIFICATIONS

T.10.3. The Forward Facing Camera selected is model VIVOTEK IP8335H.

8.10.4.- ~~**HOUSING FOR RVC AND FFC TECHNICAL SPECIFICATIONS**~~

T.10.4. The Housing for RVC and FFC is the same and its Technical Specifications are:***Not in scope of supply of SEPSA****

8.11.- REAR VIEW MONITOR TECHNICAL REQUIREMENTS

T.11.1. The Rear View Monitor will have a 9" TFT technology with a color depth of 18 bits. The resolution will be 640x480 (VGA). The TFT Monitor will have a 16:9 form factor.

T.11.2. The level of protection of the RVM in its frontal side, when it is installed, will be IP64.

T.11.3. The RVM is equipped with one (1) 10/100 Mbps Ethernet port.

T.11.4. The RVM will provide an auto-test feature. It will report to the Control Unit its status.

T.11.5. The RVM is equipped with display brightness control functionality. This may be controlled manually, through MVB commands, or automatically depending on the amount of ambient light.

T.11.6. The Ethernet connected will be M12 type.

T.11.7. The RVM will be embedded in the driver’s console..

8.12.- EXTERNAL POWER SUPPLY TECHNICAL REQUIREMENTS

T.12.1. The EPS will convert the Battery Voltage of the train (16,8Vdc to 30Vdc) to the voltage needed to power the system equipment.

T.12.2. The EPS will have protection against polarity inversions and overloads.

T.12.3. The EPS will provide 12Vdc output.

Figure 13 Example of an EPS

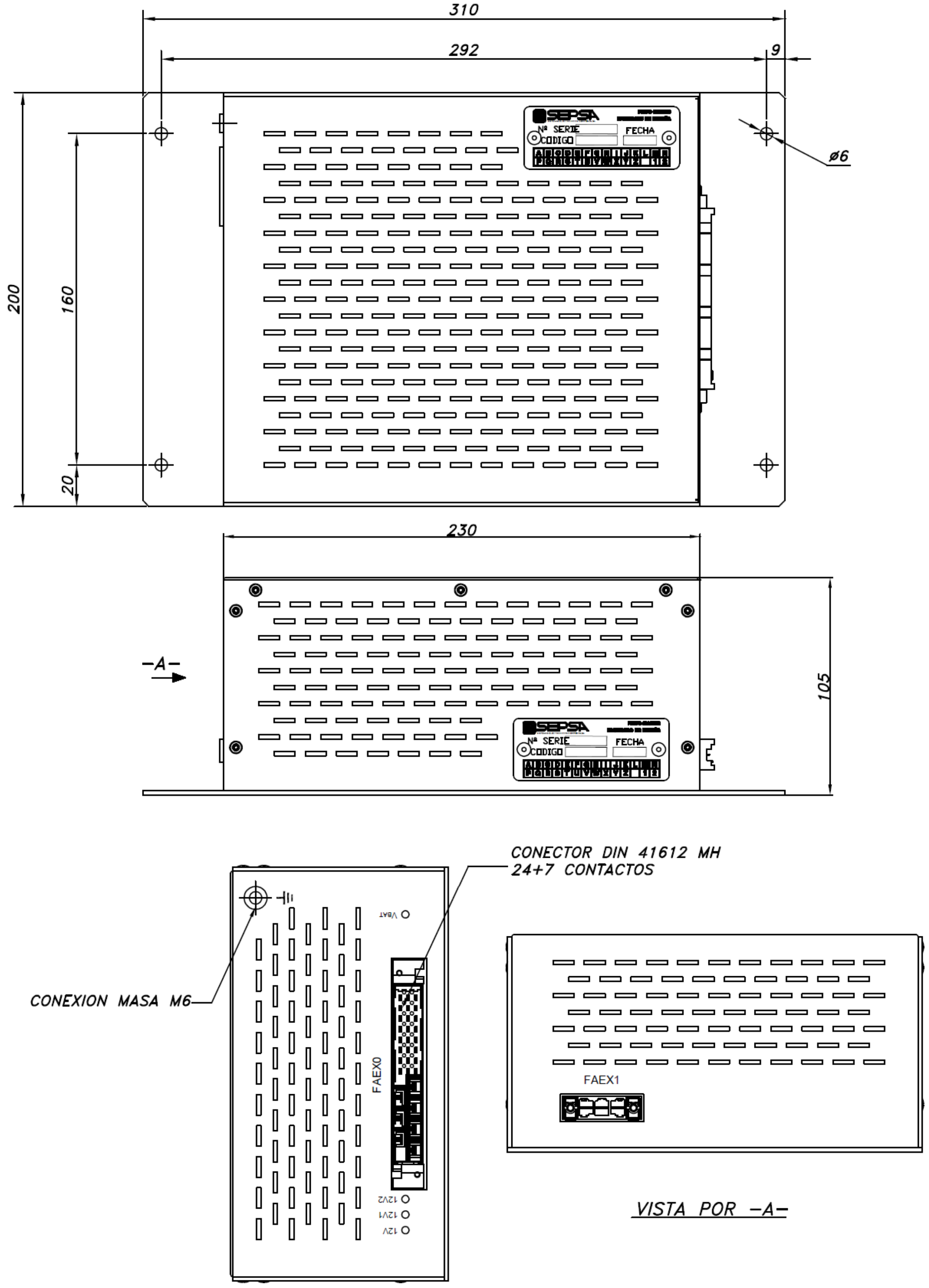


Figure 14 Drawing of the EPS (Dimensions in mm).

8.13.- CAB MICROPHONE TECHNICAL REQUIREMENTS

T.13.1. The Cab Microphone is equipped with a gooseneck microphone and a microphone previous audio amplifier.

T.13.2. The Microphone is equipped with an audio interface with the Control Unit.

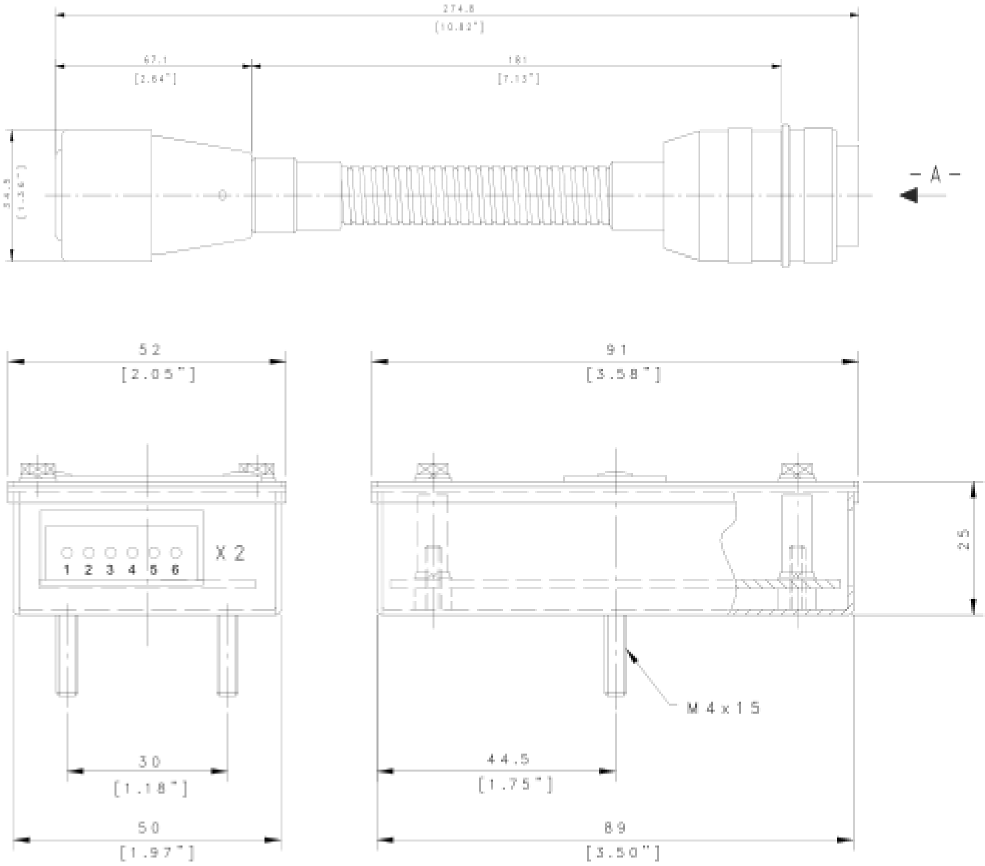


Figure 15 Schematic of a gooseneck microphone and the microphone pre/-amplifier (dimensions in mm)

8.14.- COVERT MICROPHONE TECHNICAL REQUIREMENTS

T.14.1. The Covert Microphone is equipped with a microphone and a microphone previous audio amplifier.

T.14.2. The Covert Microphone will capture the environment noise of the train driver cabin and send it to the Control Unit for recording in the Digital Video Recorder.

Figure 16 Example of a covert microphone

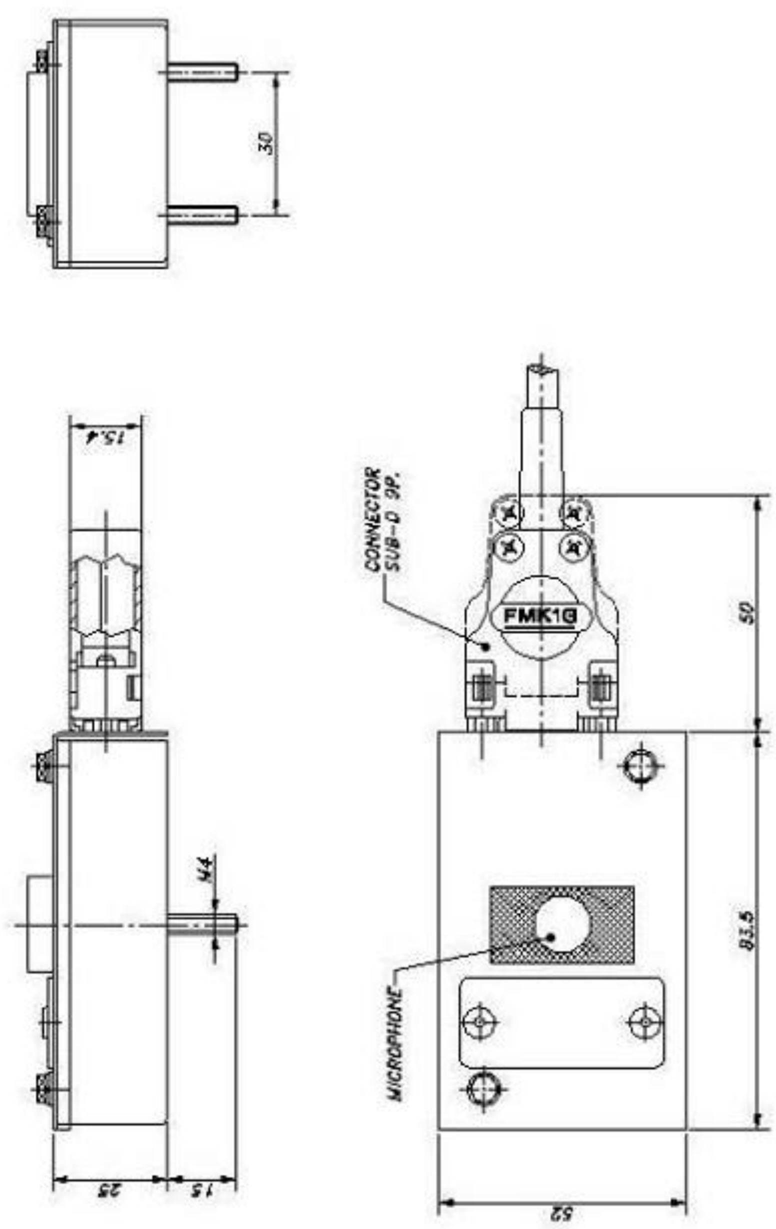


Figure 17 Views of a covert microphone (dimensions in mm)

8.15.- WEIGHT AND CONSUMPTION OF THE EQUIPMENT

T.15.1. The weight of each device will be, approximately, the following:

Devices	Weight (Kg)
Control Unit	11
Intercom INT	1
External Front Indicator (EFI)	12
External Side Indicator (ESI)	12
Internal Display (ID)	4
Cab Microphone with pre-amplifier	<1
Cab Speaker	<1
Saloon Loudspeaker	<1
External Loudspeaker	<1
Internal Camera	<1
Forward Facing Camera (FFC)	<1
Rear view Camera (RVC)	<1
Rear View Monitor (RVM)	5
Rear View Monitor Mechanical Fix	<1
External Power Supply	3,5
Switch Ethernet Module T1	1,5
Covert microphone	<1

T.15.2. The consumption of each device will be, approximately, the following:

Devices	Consumption (W)	Power Supply
Control Unit	150	Battery of the Train
Intercom INT	3	Control Unit
External Front Indicator (EFI)	39	Battery of the Train
External Side Indicator (ESI)	39	Battery of the Train
Internal Display (ID)	27	Battery of the Train
Cab Microphone with pre-amplifier	<1	Control Unit
Cab Speaker	1	Control Unit
Saloon Loudspeaker	1	Control Unit
External Loudspeaker	5	Control Unit
Internal Camera	3,5	External Power Supply
Forward Facing Camera (FFC)	3,5	External Power Supply
Rear view Camera (RVC)	3,5	External Power Supply
Rear View Monitor	35	External Power Supply
External Power Supply	The consumption of this equipment is already indicated in the consumption of the equipments that are powered from the External Power Supply.	Battery of the Train
Switch Ethernet Module T1	10	External Power Supply
Covert microphone	<1	Control Unit

APPENDIX 13.2

FUNCTIONAL DESCRIPTION PISPASPA_CCTV

ISSUE CONTROL

ISSUE	REASON	DATE
-	First issue	13/NOV/2013

DISTRIBUTION

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Signature:	**Signature:**	**Signature:**
Date: 13/Nov/2013	**Date:** 13/Nov/2013	**Date:** 19/Nov/2013

INDEX

1 PURPOSE

The purpose of this document is to present, for City of Cincinnati review and approval, the System Functional Description of the PISPASPA and CCTV Systems of the Cincinnati Streetcar.

2 ATTACHMENTS

Document	Issue	Date	Generated by
I-T09760 - System Functional Description Communication System (PIS-PAS-PA) CCTV Ethernet Network - CAF / CINCINNATI CITY	01	13.Oct.2013	SEPSA

ATTACHMENT 1. I-T09760 - System Functional Description Communication System (PIS-PAS-PA) CCTV Ethernet Network - CAF / CINCINNATI CITY

Document I-T09760	Edition 01	Date 13/10/30

System Functional Description

Communication System (PIS-PAS-PA)

CCTV

Ethernet Network

CAF / CINCINNATI CITY

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CONTROL OF EDITIONS AND MODIFICATIONS

EDITION	**MODIFICATIONS**
00	Base Edition
01	Title changed to "System Functional Description". Replaced 16 ports switch in car S1 for 24 ports switch. Removed 2 side displays in C1 and C2 cars. Added 2 side displays in S1 car. Changed Saloon speaker distribution from 2-4-2 to 3-4-3. Included/removed information previously marked as "pending". Replaced example display pictures with mock-ups of the final design. Added note for rearview camera to be placed in a protective enclosure. Updated Interior and Frontal Display drawings.

EDITION	DATE	PREPARED	CHECKED	APPROVED
01	13/10/30	Vincenzo Auteri	Javier López, Pablo Izquierdo	Javier Elena
00	13/09/23	Vincenzo Auteri	Javier López, Pablo Izquierdo	Javier Elena

CONTENTS

1.- OBJECT

This document is meant to provide a functional description and an overview of the various systems and subsystems of which the Communication and CCTV System developed by SEPSA is composed.

It's not meant to be a detailed description of requirements, interfaces or HW/SW design, for which the following documents are to be consulted:

- Technical Specification (for detailed Functional and Technical Requirements).
- External Interfaces
- Software Design Description
- Hardware Design Description
- MVB variable list

In the case of those devices where an independent design package was required, a slightly more detailed description of the Hardware and Software is given.

2.- SCOPE

This Technical Description applies to the Communication and CCTV System, which will enter into service in the new Streetcars manufactured by CAF for CINCINNATI CITY.

The Communication and CCTV System will be, henceforth, named IRISD+CCTV System or System.

3.- APPLICABLE STANDARDS

3.1.- DOCUMENTS OF SEPSA-SCI

S064002-E	Ed B	General Diagram
E-T02991		Technical Specification
G-T03429		External Interfaces

3.2.- STANDARDS AND OTHER DOCUMENTS

EN-50155	Electronic equipment used on rolling stock.
ISO/IEC 7498-1	Open Systems Interconnections – Basic Model
IEC 61375	Train Communication Network

4.- DEFINITIONS AND ACRONYMS

ACH	Audio Control Head
CCTV	Closed-Circuit of Television. (Onboard Video Monitoring System).
CS	Cab Speaker
CT	Cab Terminal
CU	Control Unit
CPU	Central Processing Unit.
DIV	Vehicle Identification Device
DVR	Digital Video Recorder
EB	Ethernet Backbone
EFI	External Frontal Indicator
EL	External Loudspeaker
EPS	External Power Supply
ESI	External Side Indicator
FFC	Forward Facing Camera
HD	Hard Disk
I2C	Inter-Integrated Circuit
IC	Internal Camera
ID	Internal Display
INT	Intercommunicator, Intercom
IRISD	SEPSA-SCI's digital Communications and Passenger Information System. (Onboard Emergency Interphones and Public Announcement System
LED	Light Emitting Diode
MIC	Microphone
MVB	Multifunction Vehicle Bus
PA	Public Address
PS	Power Supply
PC	Portable Computer
PIS	Passenger Information System
PTT	Push To Talk
PTU	Portable Test Unit
PS	Power Supply
RVC	Rear view Camera
RVM	Rear view Monitor
SL	Saloon Loudspeaker
SD	Secure Digital memory card
SWEM	Switch Ethernet Module
TCMS	Train Control and Monitoring System

TCN	Train Communication Network
TU	Train Unit
USB	Universal Serial Bus

5.- RESPONSIBILITIES

The Technical Project Manager is responsible for maintaining and updating this Technical Description.

6.- WORKING ENVIRONMENT

SEPSA's PA/PIS/CCTV System is developed for the Streetcar type trains built by CAF, commissioned by the City of Cincinnati and operating in Cincinnati, Ohio, USA.

The Streetcars will circulate in the open, with mixed traffic.

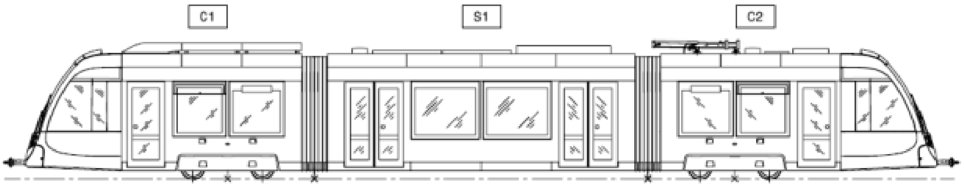


Illustration 1: Vehicle side view

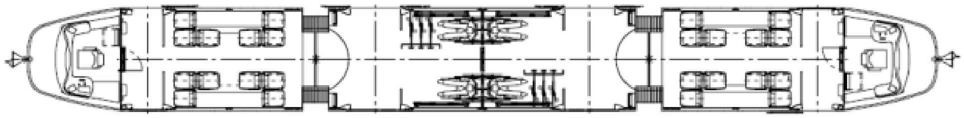


Illustration 2: Train unit top view

Drawing 1 - Streetcar front and side view (CAF)

CAF's platform is a compact, symmetric, manned train, with 24,4m total length.

It's composed by 3 cars, of which only the two cabs (C1 and C2) are connected to the railway, while the middle car (S1) is suspended and there is no contact with the rail.

There is no regular service when the unit is coupled; it is possible for a Train Unit to tow another. The only functionality the SEPSA's system has to provide in this mode is a inter-unit CAB to CAB audio connection. There is not shared Ethernet connection between coupled units in towing mode.

7.- GENERAL TECHNICAL DESCRIPTION OF THE SYSTEM

7.1.- GENERAL OVERVIEW AND DESIGN PRINCIPLES

SEPSA's system for the Cincinnati Streetcar is composed by these major blocks:

- Ethernet Network: manages the Ethernet backbone and provides access and network services to the devices connected to it.
- PIS-PA: manages the Passenger Information audio connections in the train, as well as providing audio and visual automated announcements.
- CCTV: Records and stores video stream from the cameras installed on the train, as well as visualizing rearview cameras' streams in real-time.

Each of these blocks is composed by a number of sub-systems, which will be discussed in detail in separate sections.

Although these major blocks are discussed separately, they are fully integrated together and communicate constantly with each other using similar internal interfaces.

The main ideas behind SEPSA´s global system (internally known as the "Integrated System", and from now on referred simply as "System") are:

- Ethernet communication: all the devices connected to the System communicate between each other using protocols at the Application level of the OSI model, and make use of a subset of those defined in the lower levels. Ethernet technology offers a modern standard that can adapt to different bandwidth conditions, different communication paradigms (connection oriented and connectionless), and offers a number of standard application protocols (FTP, telnet, http) that can be used as a support for development and maintenance.
- Integration and Modularity: the System is currently into service in a large number of passenger trains, which vary in terms of car configuration, type and number of devices installed, working environment and functionalities offered. Customizing the System for a new service is relatively simple: different functionality can be added or removed simply by modifying the configuration of the boards installed in the Control Unit, or the devices connected to the Ethernet ports. Using common technology and interfaces for the various part of the System allows for optimizing space (cabling, physical devices), and time (development and debugging).
- Control based on state rather than on events: one of the main challenges of an embedded system developed for use in a railway environment is to keep track of a large number of variables and to keep the internal state of the various devices coherent and synchronized between them. A device connecting to the system experiencing a temporary failure must be able to restart and update its state to reflect the state of the system. For this reason all the devices publish

their state, as groups of variables, constantly and continuously regardless of whether there has been a change. This way the System can ensure full synchronization between the various devices and be responsive to changes.

- Digital audio and video: all the media processed by the system is digitized in order to be transmitted over Ethernet. Video and audio are encoded at the origin and transmitted to destination when they are either decoded and played (for example in the case of Cab-Intercom connection, or the rearview cameras) or stored for recording and later viewing (internal cameras and environmental audio in cabs). This allows for minimizing the quality loss of the signal.

7.2.- SYSTEM OVERVIEW

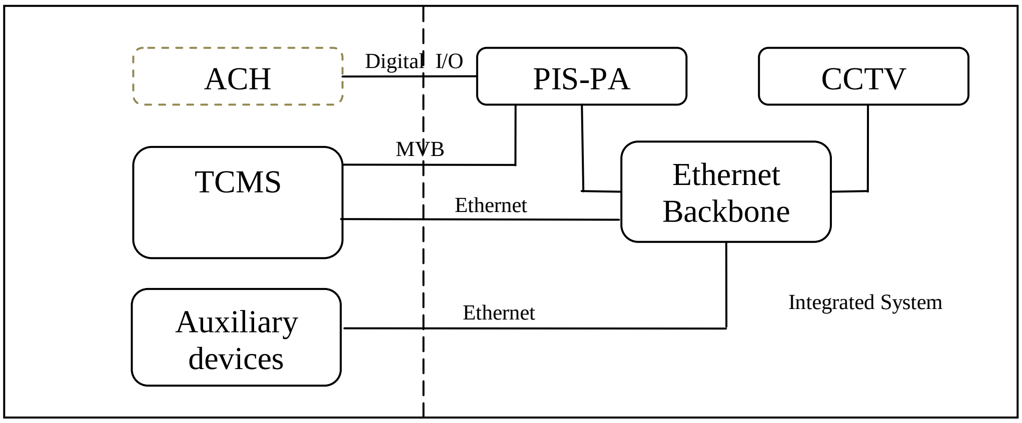


Diagram 1 - System division in functional blocks

- The Ethernet Backbone is composed by devices that provide the communication infrastructure serving as the physical internal interface between the PIS-PA System and the CCTV System, and part of the external interface between the Integrated System and the other devices on the train. It is also responsible for separating the network domains through VLANs and to regulate the traffic in the network. It implements a Type-E network as defined by IEEE 1473.

- The PIS-PA includes all the devices in the Integrated System that provide Audio and Visual communications features. This part of the system also serves as the main interface with the remaining systems on the Streetcar.

- The CCTV system provides video recording and visualization functionality, managing the all the cameras installed on the train. It doesn´t communicate directly with the external systems, but only through the PIS-PA system.

8.- ETHERNET BACKBONE

The Ethernet Backbone provides the main physical communication interface for the devices in the Integrated System, and part of its external interface. In addition to that, it also provides access to a maintenance network for auxiliary equipments.

The devices that this part of the System is composed of and their distribution in the train are:

Devices	C1	S1	C2
8 Ports Embedded Switch (CU)	2	0	0
4 Ports Embedded Switch (CU)	2	0	0
24 Ports Independent Switch	0	1	1

Table 1 - Switches distribution on the Streecar

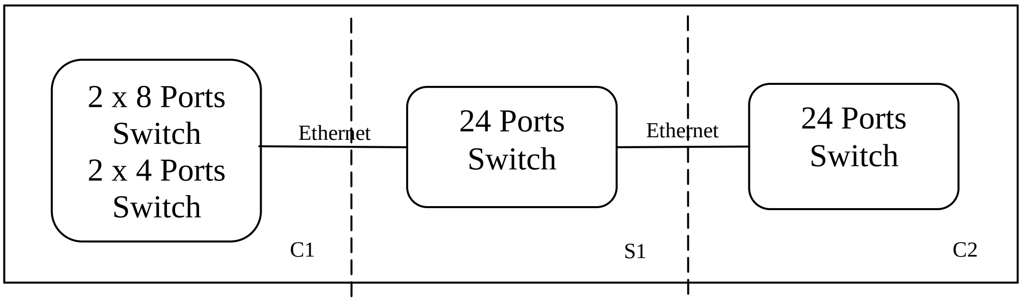


Diagram 2 - Distribution of the switches on the Streetcar

The standard for transmissions on the network will be 100Base-TX, becoming the maximum bit rate 100 Mbps per link. The backbone connection between switches will operate at a maximum rate of 200 Mbps.

The physical interfaces of the network Switches allow for the negotiation of different speeds, in order to adapt themselves to any kind of auxiliary equipment that might connect to them. Specifically, they support the negotiation of 10Base-TX and 100Base-TX.

The Switches are proprietary SEPSA's devices. They provide the characteristics of the Vehicle Switch as listed in Table 5 of standard IEEE 1473.

8.1.- EMBEDDED SWITCH

8.1.1.- DESCRIPTION

These Switches are embedded in the 6U Control Unit installed in the C1 car. The Control Unit houses various boards of the Integrated System, and these boards are interconnected between themselves though a main board situated on the backplane of the CU.

The SWE circuit boards are installed in the unit by sliding them towards the back along the pair of plastic guides and plugging the connector at the bottom of each board with the corresponding one mounted on the CU

backplane. The connectors of the boards have hard plastic coding pins, meant to match only the correct mate on the backplane, so that is impossible to install the board in the wrong slot.

The two switches installed in the CU are physically identical and carry exactly the same software product. They differs only in the configuration of the microswitches in the bank mounted on the board.

The different configurations are used to identify each switch as the Master Switch (which provides the interface with the main boards in the unit) and the Slave Switch(which provides additional ports for exterior and auxiliary devices).

The Embedded Switch is powered up using 12V DC voltage, generated by the Power Supply embedded in the CU.

8.1.2.- COMMUNICATION INTERFACES

Each Embedded Switch provides a total of 16 Ethernet connections. 8 Ports are wired to the backplane of the CU, and connect the other boards of the System present on the CU to the train Network. A subset of the unused ports is made available for connecting exterior devices through the 4 Ports Embedded Switches.

In addition to the back Ports, the Switch has 8 Ports in its front, used to connect external devices through M12 Ethernet connectors.

8.1.3.- USER INTERFACES

There are two rows of LEDs laid vertically in between the ports: the ones bearing a numbered text show the traffic status of each of the Ehternet channels, while the bottom ones are for debugging and internal use.

The SD slot on the front is used to update the firmware, while the USB port is for maintenance and internal use.

8.2.- PASSIVE EMBEDDED SWITCH

8.2.1.- DESCRIPTION

The Passive Embedded Switch is wired through the backplane of the CU to a subset of the unused back ports of the 8 Ports Embedded Switch.

This way, 4 unused back ports of the Embedded Switch can be utilized without adding additional Embedded Switches.

8.2.2.- COMMUNICATION INTERFACES

The Switch provides 4 Ethernet ports on its front, to which external devices can be connected though M12 connectors.

8.3.- 24 PORTS INDEPENDENT SWITCH

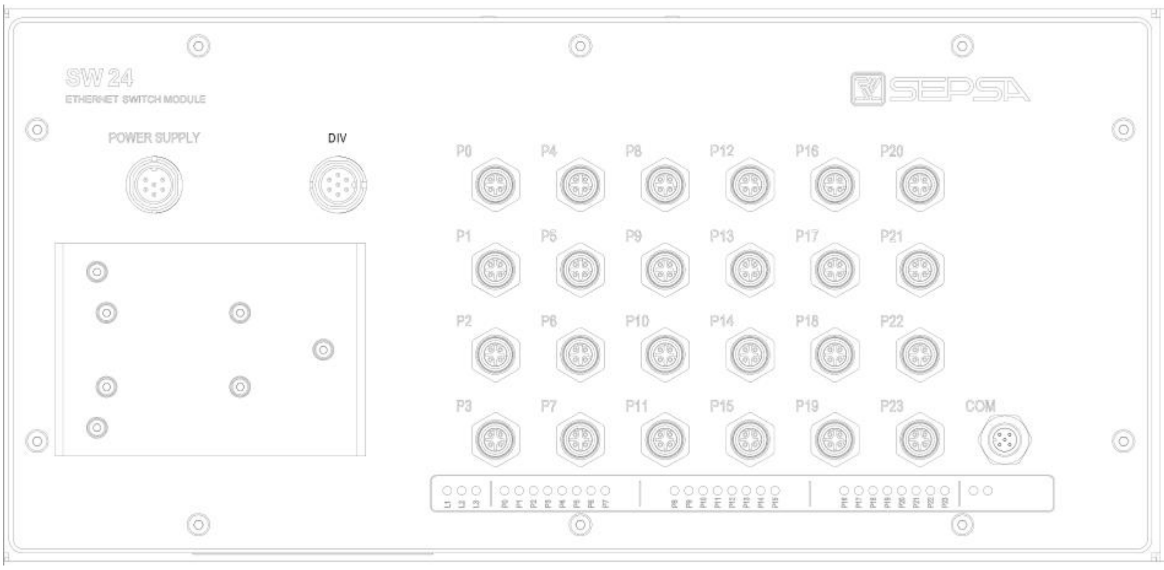
8.3.1.- DESCRIPTION

The 24 Ports switches are independent devices (not embedded in a CU) and provide 24 Ethernet Ports, to which external devices can be connected by using M12 Ethernet connectors.

Although with a different form factor, the Switch is functionally identical to an 8 Ports Embedded Switch.

The Switch is powered up by 12V voltage, generated by SEPSA's external Power Supply, installed in the S1 car, though the round 6 pins connector marked with "POWER SUPPLY".

The 7-pins round connector marked as "DIV" is meant to be connected to a special connector housing a non-volatile E2PROM memory, which is used to save configuration information, as train unit and car numbers.



Drawing 2 - 24 Ports Switch front view

8.3.2.- COMMUNICATION INTERFACES

The Switch provides 24 Ethernet ports on its front, to which external devices can be connected by using M12 connectors.

8.3.3.- USER INTERFACES

A bottom row of LEDs are used to provide visual feedback. The ones marked with L1, L2 and L3 are used for showing the general status of the device (for more information consult the user manual), while the ones bearing a numbered text show the Ethernet traffic coming though the corresponding Ethernet ports.

8.4.- NETWORK ARCHITECTURE

8.4.1.- DESCRIPTION

The Switches in the CU in car C1 and the 24 port Switches in cars S1 and C2 are connected to each other using two twisted pair Ethernet cables, using port trunking, effectively doubling the available bandwidth allowed by a single cable connection, as well as providing redundancy.

The ports 0 to 3 of each Switch are dedicated to the backbone connection. If both cables connecting two switches are plugged in and in working order, then a bandwidth of 200 Mbps will be available between the two switches.

The remaining devices, both parts of SEPSA's PIS/PA/CCTV system, as well as auxiliary equipments, are connected to the available ports of the switch installed in the car.

Each device is connected exactly to a single port, which is not shared with any other device, giving the network a star arrangement, thus minimizing the possible failures due to cabling faults.

The network provides two main functions:

- Distributing in digital format all the audio, video and auxiliary data traffic needed by the SEPSA's System to carry out its function, as well as providing maintenance access to its devices.

- Providing maintenance access to the auxiliary devices (not belonging to SEPSA's System) connected.

Although the switches can support separate VLANs in the network, in this system the separation of the System's own network from the auxiliary network has not been considered necessary, since the expected traffic from the auxiliary devices is not relevant in terms of required bandwidth. This choice simplifies the network's design.

Each device is assigned an IP address using the DHCP protocol, and a DNS name, with which is addressed by the other hosts on the network. The CPU of the PIS system serves as the DHCP and DNS server.

The systems onboard (maintenance laptops included) will be able to make use of the DNS service to get the IP of the other systems connected to the network if they need it.

The DHCP server will provide information about the available DNS servers.

The network established has a range (in CIDR notation) of 10.0.0.0/8, and uses an internal logic based on the unit/car number in addition to an identifier specific to the host.

The following alphanumeric string will be used as logical identifier:

`SYSTEM.CAR.UNIT.TREN`

TREN is fixed for all devices.

UNIT is composed by the text string `UTN` and by two other digits representing the train unit for example `UTN01` for the train unit number 1.

CAR is one of: `C1`, `S1`, `C2`

SYSTEM is specific to each host, usually a combination of a name, depending on the host type, and optionally a number, if there is more than one device of the same type in the car.

A table with all the System's DNS names for each host will be provided in a Technical Report about the Ethernet Network.

9.- PASSENGER INFORMATION SYSTEM AND PUBLIC ANNOUNCEMENT

The PIS/PA subsystem provides all the functionality related to audio and video communications and automatic announcement (audio and video), as well as serving as the main control point of the whole System, interfacing with the TCMS through the MVB bus and Ethernet.

It also provides the main maintenance interface to the System, running on a web server accessible from the SEPSA's Ethernet network.

It includes the main CPU, Audio Matrix, Amplifier, MVB, Digital I/O boards installed in the Control Unit, and all the Displays, Intercoms, Speakers and Microphones.

The main functions of the PIS/PA system are:

- Manage the public address audio connections. These connections are : Public Address (Driver to Passengers, one-directional), Radio Public Address, Special (pre-recorded) Message to Passengers, (pre-recorded) Route Announcement to Passengers, Passenger Stop request, Doors closing warning.
- Manage the intercommunication audio connections. These connections are: Cab-to-Cab (local unit), Cab-to-Cab (to other unit, in towing mode), Cab-to-Intercom (bidirectional, half-duplex).
- Manage audio connections priorities. Connections that do not share resources will be able to be established concurrently. Proposed order is:
  - Door warning
  - PA
  - Radio-PA
  - Cab-to-Cab (local)
  - Cab-to-Cab (towed unit)
  - Cab-to-Intercom

    - Passenger Stop Request
    - Special Message
    - Automatic Announcement
- Manage the automatic route announcer. Once the route is manually loaded by the Driver, the System is able to position itself correctly along the route using dead-reckoning, and announce the stops accordingly.
- Manage communications with the external systems.
- Manage all the peripheral devices used by the System (Displays, Intercoms, Rearview Monitors).
- Offer a maintenance interface (web application) through which the staff can monitor the system's status, download the faults log, and visualize/modify the current configuration and software versions.

The distribution of the various devices involved in the PIS/PA function on the train is the following:

Devices	C1	S1	C2
PIS CPU (CU)	1	0	0
Audio Matrix (CU)	1	0	0
Amplifier (CU)	1	0	0
Digital I/O (CU)	2	0	0
MVB (CU)	1	0	0
Power Supply (CU)	1	0	0
External Power Supply	0	1	0
Frontal Display	1	0	1
Side Display	0	2	0
Interior Display	1	2	1
Intercom	1	2	1
Saloon Speaker	3	4	3
Cab Speaker	2	0	2
Exterior Speaker	2	0	2
Cab Microphone and PreAmp	1	0	1
Covert Microphone	1	0	1

Table 2 - PIS devices distribution on the Streetcar

9.1.- CONTROL UNIT

The Power supply, PIS CPU, Audio Matrix, Amplifier, MVB, Digital I/O circuit boards are embedded in the 6U Control Unit installed in the C1 car. The Control Unit houses various boards of the Integrated System and these boards are interconnected between themselves through a main board situated on the backplane of the CU.

The boards are installed in the enclosure by sliding them towards the back along the pair of plastic guides and plugging the connector at the bottom of each board with the corresponding one mounted on the CU backplane. The connectors of the boards have hard plastic coding pins, meant to match only the correct mate on the backplane, so that is impossible to install the board

in the wrong slot.

9.2.- PIS CPU

9.2.1.- DESCRIPTION

The PIS CPU is the main intelligent agent of the Integrated System. It contains the main control logic, it coordinates the communication between all the boards and devices and interfaces with the external systems on the train.

- Serves as the DHCP and DNS server for the SEPSA Train Network.
- Reads the configuration information in the DIV non-volatile memory.
- Processes the inputs coming from the Digital I/O board and actuates the outputs.
- Processes the data coming from the ports imported by the MVB board and updates the data of the exported ones.
- Controls the Audio Matrix, establishing the audio connections according to the user commands and the priority list.
- Controls the Intercoms, establishing the driver-passenger communication.
- Controls the LED Displays, sending commands coming from the announcer in order to display text.
- Holds the announcer configuration data, and contains the logic to generate automatic announcer events.
- Provides the interface between the CCTV subsystem and the external Systems (TCMS).
- Proves the main maintenance interface for the user.

The CPU has a SD card slot on the PCB. It is used to update the software, to hold announcer configuration data and maintenance log data.

The software can be updated either using the SD card or remotely, using a proprietary application, that will be part of the software installed in the maintenance laptop.

9.2.2.- COMMUNICATION INTERFACES

- The CPU is a host on the SEPSA's Train Network, and it is connected to an Ethernet port of an Embedded Switch board through the backplane of the CU. This is the main communication interface

with the Audio Matrix, Intercoms, LED Displays, SVV (part of the CCTV subsystem) and Recording Cameras (part of the CCTV subsystem). The DNS name of the CPU in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `SIV`.

- The CPU has a secondary Ethernet port on its front, which can be used as a maintenance access connecting a maintenance laptop to it with a RJ45 cable. When connecting to the CPU to this port, the interface will have a fixed ip address of 169.254.0.5.

- The CPU is connected to the Power Supply board through the backplane of the CPU. Apart from receiving power, it can read the status of the Power Supply and access the DIV non-volatile memory present in the connector of the passive board of the PS though an I2C bus.

- The CPU is connected to the Digital I/O board using memory mapped I/O, though the backplane of the CU.

- The CPU is connected to the MVB board using memory mapped I/O, though the backplane of the CU.

9.2.3.- USER INTERFACES

On the front of the boards there are three rows of LEDs.

The first row displays the data traffic coming through the two Ethernet ports of the boards.

The bottom two rows (leds marked L1-L8) have debugging purposes and show system status.

Leds L1-L4 display whether the System is working normally, while leds L5-L8 are used to show if specific functionalities are available (MVB, Announcer).

For a detailed description of the LEDs significance please consult the User Manual of the PIS System.

The main maintenance and monitoring interface for the user is the PMM interface.

The PMM is an http web server running on port 80 of the PIS CPU host. The user is able to perform many maintenance and monitoring tasks by connecting a laptop to a Switch maintenance port, and typing the PIS CPU ip or DNS address on a Firefox web browser.

The PMM is password protected, and has the possibility of being loaded

either in English or Spanish.

Using the PMM interface the user is able to:

- Configure the unit number to which the CU belongs to (necessary for the correct functioning of the System)
- Configure volume levels for each connection.
- Monitor in real time the status of each board and device connected to the system via Ethernet.
- Download/Delete the maintenance log.
- Print the software versions of each board/system connected to the network.
- Perform route simulations.
- Send special messages.

For a detailed description of PMM's features please consult the User Manual of the PIS System.

9.3.- EMBEDDED POWER SUPPLY

9.3.1.- DESCRIPTION

The embedded power supply receives the 24Vdc train's battery power voltage and outputs 12Vdc and 5Vdc voltages, used to power up all the boards installed in the CU as well as the Cab Microphone Pre-Amplifier.

The Power Supply is made up of two boards: a passive board with a connector on its front and the active board where the actual DC-DC conversion is carried out.

The passive board routes the power lines from the external systems to the active one. In addition, it provides access to the DIV memory and provides status information about the health of the PS through an I2C bus.

The DIV memory is a non volatile memory, embedded in the external connector to be plugged in the passive PS board. It contains configuration data needed by the system to work properly (train unit number, car type, volume levels).

There is no software product installed on the PS boards.

9.3.2.- **COMMUNICATION INTERFACES**

The passive board is connected to the CPU SIV though the connector to the backplane of the CU, using an I2C bus.

9.3.3.- **USER INTERFACES**

There are four leds on the front of the active board. Each lead provides status information about the health of the DC power inputs/outputs.

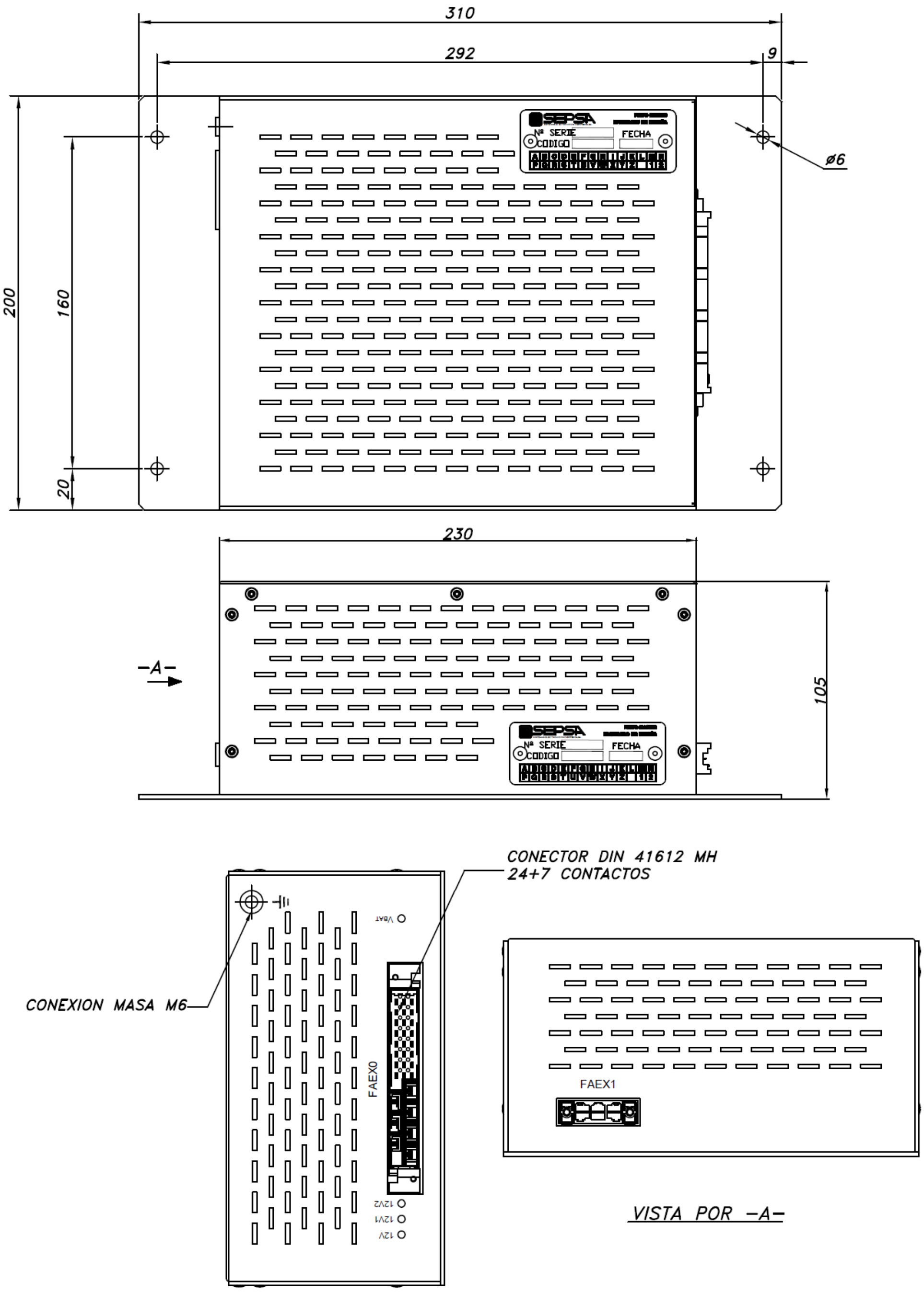
For a detailed description of the LEDs significance please consult the User Manual of the PIS System.

9.4.- EXTERNAL POWER SUPPLY

9.4.1.- **DESCRIPTION**

The external power supply receives the 24Vdc train's battery power voltage and outputs 12Vdc voltage, used to power up these external devices connected to the SEPSA's System.

Image 1 - External Power Supply unit



Drawing 3 - External Power Supply

The EPS has three separate 12Vdc outputs, one of which is always on, while the latter two can be controlled using digital inputs routed to the connector.

The EPS powers the following devices belonging to SEPSA's System: 16 and 24 ports external Switches, Intercoms, Covert Microphone, Internal, Frontal and Rearview Cameras, Rearview Monitor.

There is no software product installed on the EPS board.

9.4.2.- COMMUNICATION INTERFACES

Two digital inputs can be used to control two of the power outputs of the boards.

9.5.- AUDIO MATRIX

9.5.1.- DESCRIPTION

The Audio Matrix is a circuit board installed in the C1 car. It listens to the commands from the PIS CPU and it is responsible for establishing all the audio connections on the train.

It routes the audio input channels, coming from the connector on the front of the boards, to the desired output channels, through either the front connector or through the connector plugged in the backplane of the CU (for those connections amplified by the Amplifier board)

It also performs analog/digital audio conversion, using a dedicated DSP chip, so that digital audio streams can be and sent and received over Ethernet.

The application software runs on a customized Linux distribution.

9.5.2.- COMMUNICATION INTERFACES

- The AM is a host on the SEPSA's Train Network, and it is connected to an Ethernet port of an Embedded Switch board through the backplane of the CU. This is the interface used to communicate with the PIS CPU. The AM listens to the changes in the PIS CPU status and establishes the audio connections based on the orders received. The DNS name of the AM in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `MA`.

- The AM receives the following audio inputs :

    - Cab microphone of Car C1
    - Cab microphone of Car C2
    - Covert microphone of Car C1
    - Covert microphone of Car C2
    - Radio audio output of Car C1
    - Radio audio output of car C2

- The AM controls 6 audio outputs, which are wired to the Amplifier board through the connector connected to the backplane of the CU.

- The AM controls the amplification level for each connection amplified through the Amplifier board, though a SPI bus.

9.6.- AUDIO AMPLIFIER

9.6.1.- DESCRIPTION

The Audio Amplifier is responsible for receiving the audio inputs from the Audio Matrix and amplifying the signals to the desired level.

It is powered up by 12Vdc and 5Vdc voltages, generated by the embedded power supply.

The amplifier accepts inputs in the 1Vrms range and outputs audio in the 70Vrms level. Its rated frequency range is between 100Hz and 20kHz.

Input impedance of the audio channels is rated 600Ohms.

9.6.2.- COMMUNICATION INTERFACES

- The Amplifier receives 6 audio inputs, coming from the Audio Matrix, and wired through the connector plugged in the backplane of the CU.
- The Amplifier controls the following audio outputs, wired to the connector on the front of the board :
  - Output to Interior Speakers line 1
  - Output to Interior Speakers line 2
  - Output to Exterior Speakers Left
  - Output to Exterior Speakers Right
  - Output to Cab Speakers of Car C1
  - Output to Cab Speakers of Car C2
  - Output to Cab-Cab to coupled unit
- The AM controls the amplification level for each connection amplified through the Amplifier board, though a SPI bus.

9.7.- MVB BOARD

9.7.1.- DESCRIPTION

The MVB board is embedded in the CU installed in the C1 car. It is the main medium of communication with the Train Control and Management System.

The board acts as a Class 2 MVB node, in the Train´s MVB bus.

This allows the System to import status variables (ports) from the TCMS, necessary to for it to work correctly (i.e. alive signal, date/time, noise/occupation levels) as well as commands (load route, send message, establish connection).

At the same time the System exports its status (i.e active connection, route loaded, intercom active), necessary for the TCMS to monitor possible faults and errors, and provide feedback to the driver.

For a detailed list of the Exported/Imported MVB variables and their significance please refer to the MVB document for the project.

9.7.2.- COMMUNICATION INTERFACES

- The MVB board has no intelligence of its own and its bus controller is managed by the PIS CPU though memory mapped I/O. The two boards are connected though the backplane of the CU.

- The MVB board has two DB9 9-pins connectors on its front, one male and one female, which are used to connect the board to the MVB bus, and comply with the IEC 61375-1 Especificación TCN.

9.8.- DIGITAL I/O BOARD

9.8.1.- DESCRIPTION

The digital I/O boards are responsible for acquiring digital inputs status from outside sources, as well as controlling the digital outputs of the System.

It is the main interface with the ACH.

It has no intelligence of its own, and it is controlled by the PIS CPU.

9.8.2.- COMMUNICATION INTERFACES

- The Digital I/O board is controlled by the PIS CPU using memory mapped I/O. The board is connected to the PIS CPU through a

data/directions bus on the backplane of the CU.

- The external interface of the board is a front connector, though which all the digital inputs and outputs of the System pass through.
- Digital Inputs :
    - ACH Car C1 – PA request
    - ACH Car C2 – PA request
    - ACH Car C1 – CAB-CAB request
    - ACH Car C2 – CAB-CAB request
    - ACH Car C1 – CAB-IE request
    - ACH car C2 – CAB-IE request
    - ACH car C1 – External Speaker Selector
    - ACH car C2 – External Speaker Selector
    - ACH car C1 – Internal Speaker Selector
    - ACH car C2 – Internal Speaker Selector
    - Car C1 - Radio-PA request
    - Car C2 - Radio-PA request
    - Car C1 – Active Cab
    - Car C2 – Active Cab
    - Car C1 – Push To Talk
    - Car C2 – Push To Talk
    - Doors Open
    - Coupled Cab-Cab request.
- Digital Outputs :
    - ACH Car C1 – PA active
    - ACH Car C2 – PA active
    - ACH Car C1 – CAB-CAB active
    - ACH Car C2 – CAB-CAB active

- ACH Car C1 – CAB-IE active
- ACH car C2 – CAB-IE active
- Coupled Cab-Cab ACK.

9.9.- EXTERNAL FRONTAL DISPLAY

9.9.1.- DESCRIPTION

The External Frontal Display is a Dot Matrix LED display used to show the route number and destination to the passenger waiting on the platform.

The text shown one the system has booted is controlled at any time by the PIS CPU. It can be fully configured using the Route Database configuration tool provided with the PC system.

It has been specifically redesigned for the Cincinnati Streetcar in order to comply with size and ADA requirements.

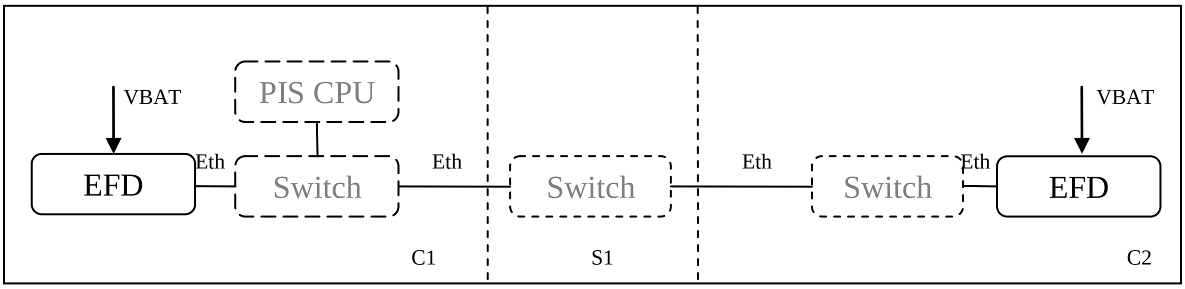


Diagram 3 - External Frontal Display distribution on the streetcar

Its dimensions have been designed so as to display 12 text characters in order to show the Streetcar's destination, and 3 additional numbers (route or train serial number).

The EFD can display either static text or text scrolling horizontally with a left-to-right motion. This is a parameter that is embedded in the orders coming from the PIS CPU.

Image 2 - External Display LED matrix example

The ID uses 150x15 amber LEDs on a black background.

9.9.2.- HARDWARE OVERVIEW

The main hardware blocks are the Power Source, CPU-Memory, LED Matrix and Ethernet Interface.

- The Power Source contains a DC-DC converter that receives the Train's 24Vdc battery voltage and converts it to 5Vdc level, powering up the rest of the system.

- The CPU runs the firmware of the EFD subsytem processing the orders from the PIS CPU and activating the LED Matrix according to the orders received and the font defined. The read-only memory stores configuration and character font data.

- The LED matrix display turns on/off the individual LEDs depending on the orders of the EFD CPU.

- The Ethernet Interface is the only communication interface of the EFD with the rest of the PC System.

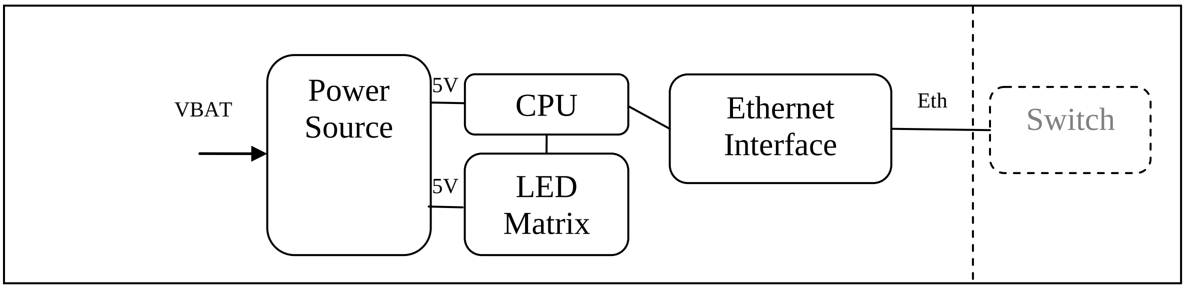
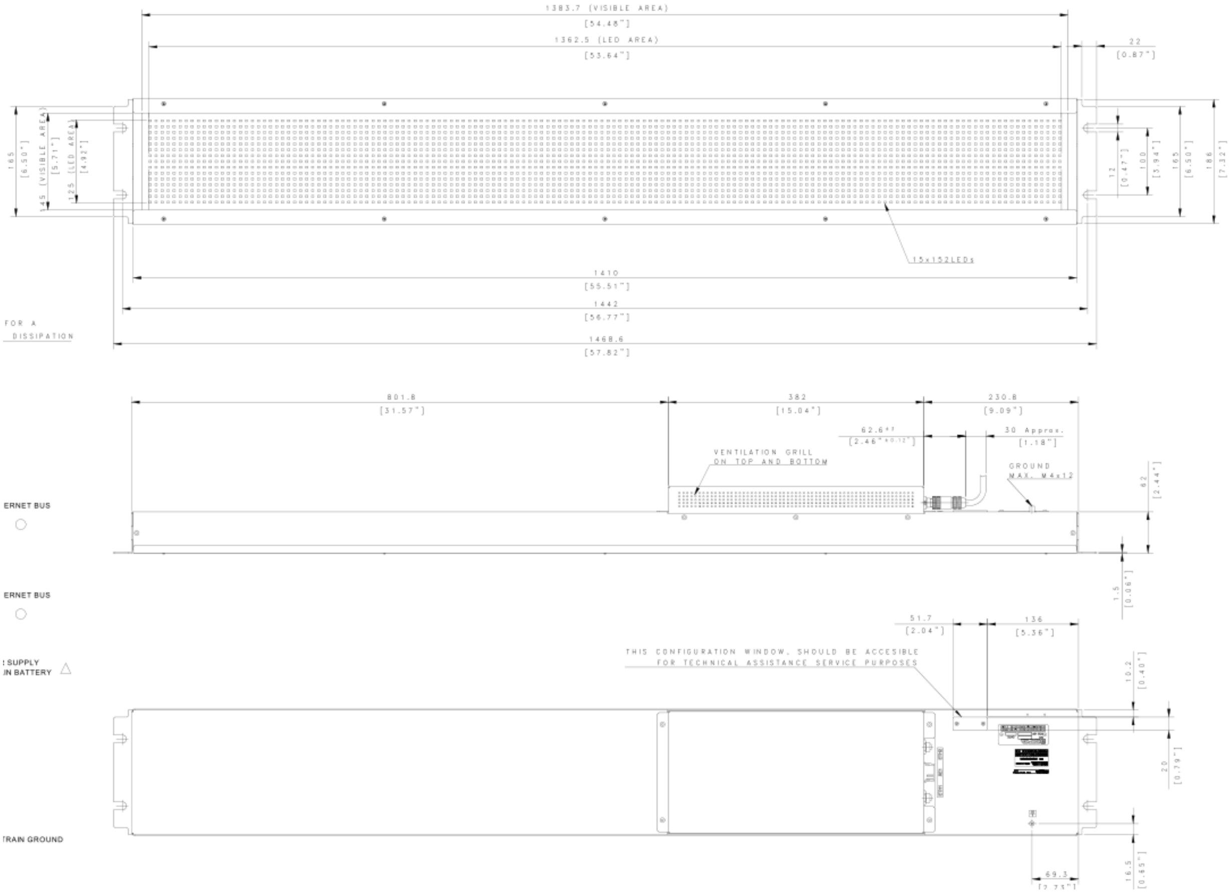


Diagram 4 - Hardware overview of External Displays

A microswitch bank, situated on the main PCB and accessible through a small panel on the back of the EFD chassis, must be configured according to the type of Display (Front, Side, Internal), so that the software can load the relevant configuration data.



Drawing 4 - External Front Display

9.9.3.- SOFTWARE OVERVIEW

The software for the EFD is composed of two different products:

- The application product contains the main executable binary, which is responsible for the control logic and the interface implementation of the EFD.

- The configuration product contains the font data and internal parameters read by the application product.

The software products are the same for each type of Display (EFD, ESD, ID), the application loads the relevant configuration data according to the positions of the microswitches.

Both products can be updated via Ethernet, using command line binaries to be executed under a Windows OS.

When booting, the Display shows its MAC address and the software product installed on its matrix display.

Once the application software has started, the EFD asks for an ip address which is given by the DHCP server running on the PIS CPU.

The EFD is identified by the port on the switch it is connected to, and is given a unique DNS name.

Once integrated in the SEPSA's Network the EFD starts sending status variables to the PIS CPU and receiving the same in return.

The PIS CPU can send orders to show text and numbers, in two distinct areas of the EFD, and to clear present text.

The internal CPU receives and processes these orders, converting text characters in patterns of on/off LEDs on the display matrix, according to the font loaded from the configuration data.

9.9.4.- COMMUNICATION INTERFACES

- Each EFD is a host on the SEPSA's Train Network, and it is connected to an external Ethernet port of either the Embedded Switch on the C1 car or the 24 ports Switch on the C2 car, depending on where it is situated. This is the interface used to communicate with the PIS CPU. The EFD listens to the changes in the PIS CPU status and listens to orders. The DNS name of the EFD in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `CF01`.

9.9.5.- USER INTERFACES

The only user interface is the LED matrix display itself, showing the result of the orders received from the PIS CPU.

9.10.- EXTERNAL SIDE DISPLAY

9.10.1.- DESCRIPTION

The External Side Display is functionally and technically identical to the EFD. It differs from it only in its installation position on the Streetcar.

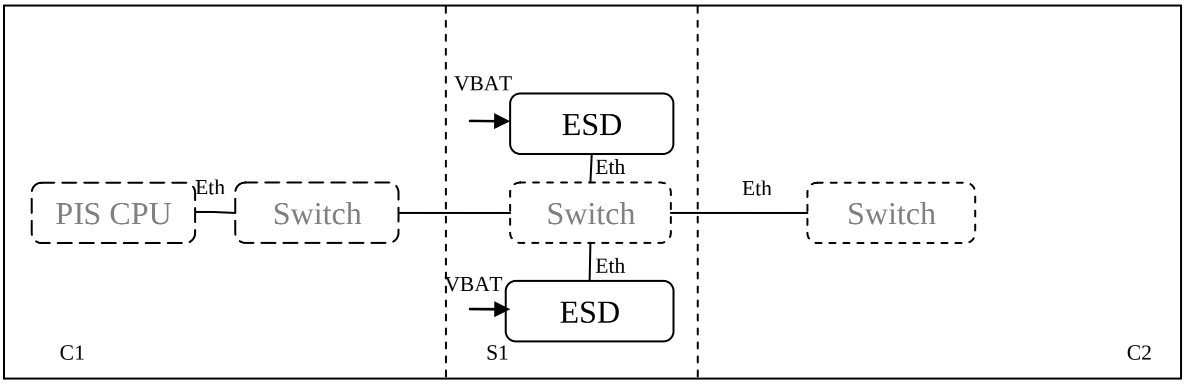


Diagram 5 - External Side Display distribution on the Streetcar

The Hardware of the ESD display is identical to that of the EFD.

9.10.3.- SOFTWARE OVERVIEW

The Software product of the ESD is the same as the one of the EFD. The application loads the relevant configuration data for this type of display depending on the microswitch bank configuration.

9.10.4.- COMMUNICATION INTERFACES

Each EFD is a host on the SEPSA's Train Network, and it is connected to an external Ethernet port of either the Embedded Switch on the C1 car or the 24 ports Switch on the C2 car, depending on where it is situated. This is the interface used to communicate with the PIS CPU. The EFD listens to the changes in the PIS CPU status and listens to orders. The DNS name of the EFD in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `CE01` or `CE02`, depending on its position in the car.

9.10.5.- USER INTERFACES

The only user interface is the LED matrix display itself, showing the result of the orders received from the PIS CPU.

9.11.- INTERIOR DISPLAY

9.11.1.- DESCRIPTION

The Interior Display is a Dot Matrix LED display used to show route and service related information (next station, destination, connection, service status) to the passengers onboard.

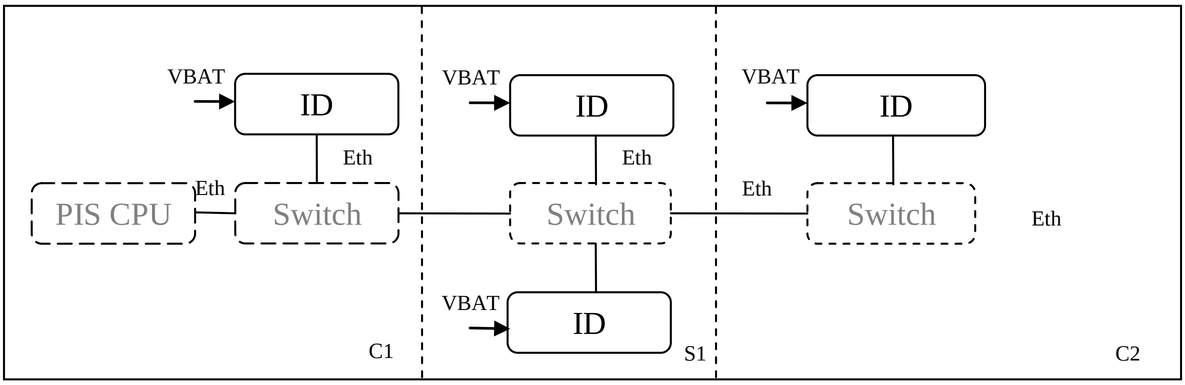


Diagram 6 - Distribution of Interior Displays on the Streetcar

It has been specifically redesigned for the Cincinnati Streetcar in order to comply with size and ADA requirements.

The ID uses 96x12 amber LEDs on a black background.

Its dimensions have been designed in order to display 12 text characters, with a font complying with ADA directives.

The ID can display either static text or text scrolling horizontally with a left-to-right motion. This is a parameter that is embedded in the orders coming from the PIS CPU. If some text is sent with a static text mode and it's longer than 12 characters it will be automatically shown in scroll mode.

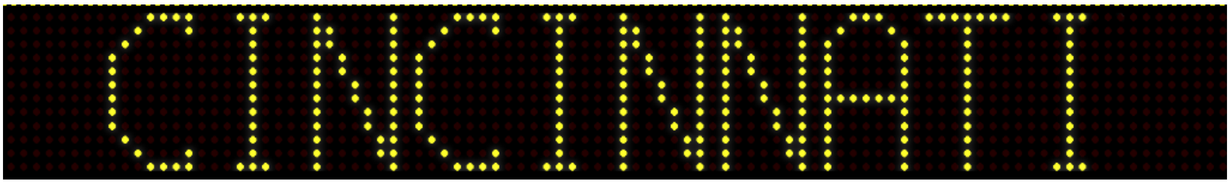
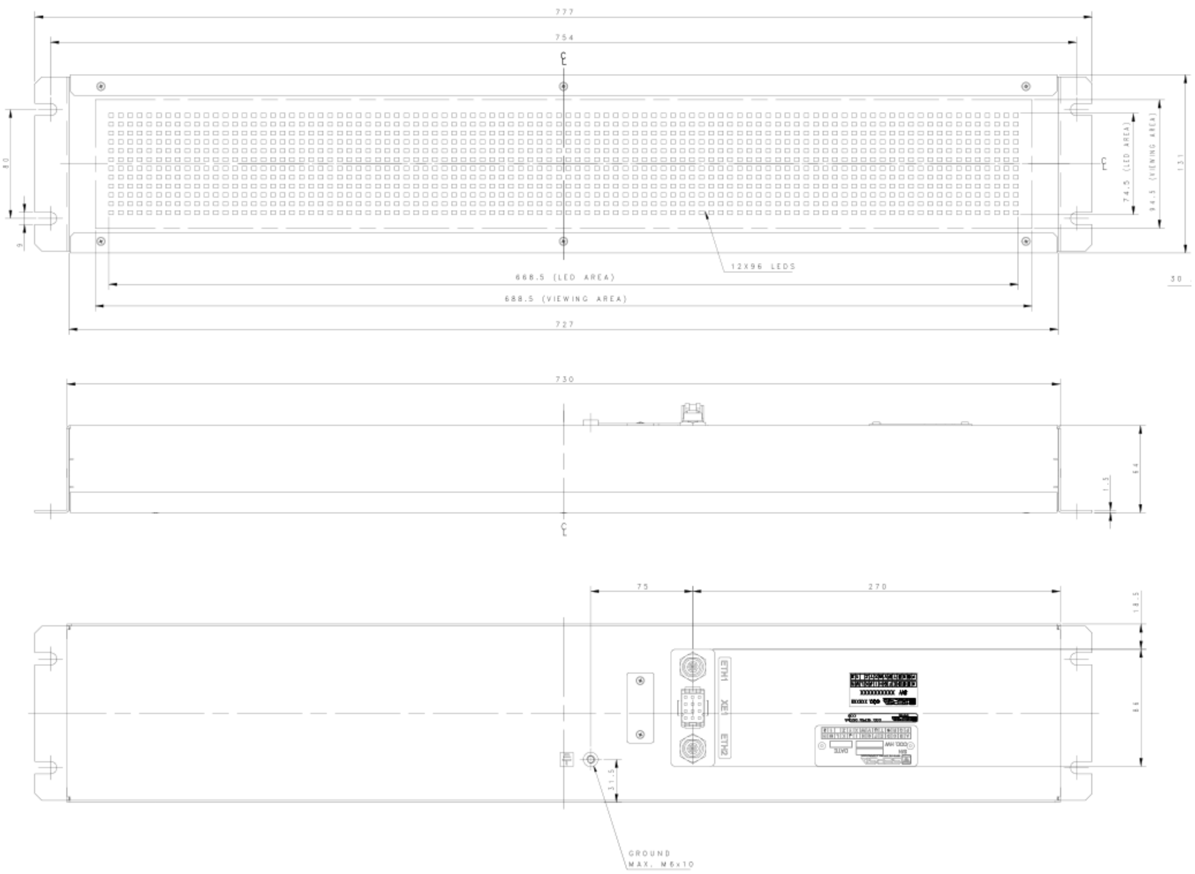


Diagram 7 - Interior Display LED matrix example

9.11.2.- HARDWARE OVERVIEW

The Hardware of the ID display is nearly identical to that of the EFD.



Drawing 5 - Interior Display

The only difference is in the different size of the LED matrix board.

9.11.3.- **SOFTWARE OVERVIEW**

The Software product of the ID is the same as the one of the EFD. The application loads the relevant configuration data for this type of display depending on the microswitch bank configuration.

9.11.4.- **COMMUNICATION INTERFACES**

Each ID is a host on the SEPSA’s Train Network, and it is connected to an external Ethernet port of either the Embedded Switch on the C1 car or the 24 ports Switches on the S1 and C2 cars, depending on where it is situated. This is the interface used to communicate with the PIS CPU. The ID listens to the changes in the PIS CPU status and listens to orders.
The DNS name of the EFD in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `CI01` or `CI02`, depending on its position in the car.

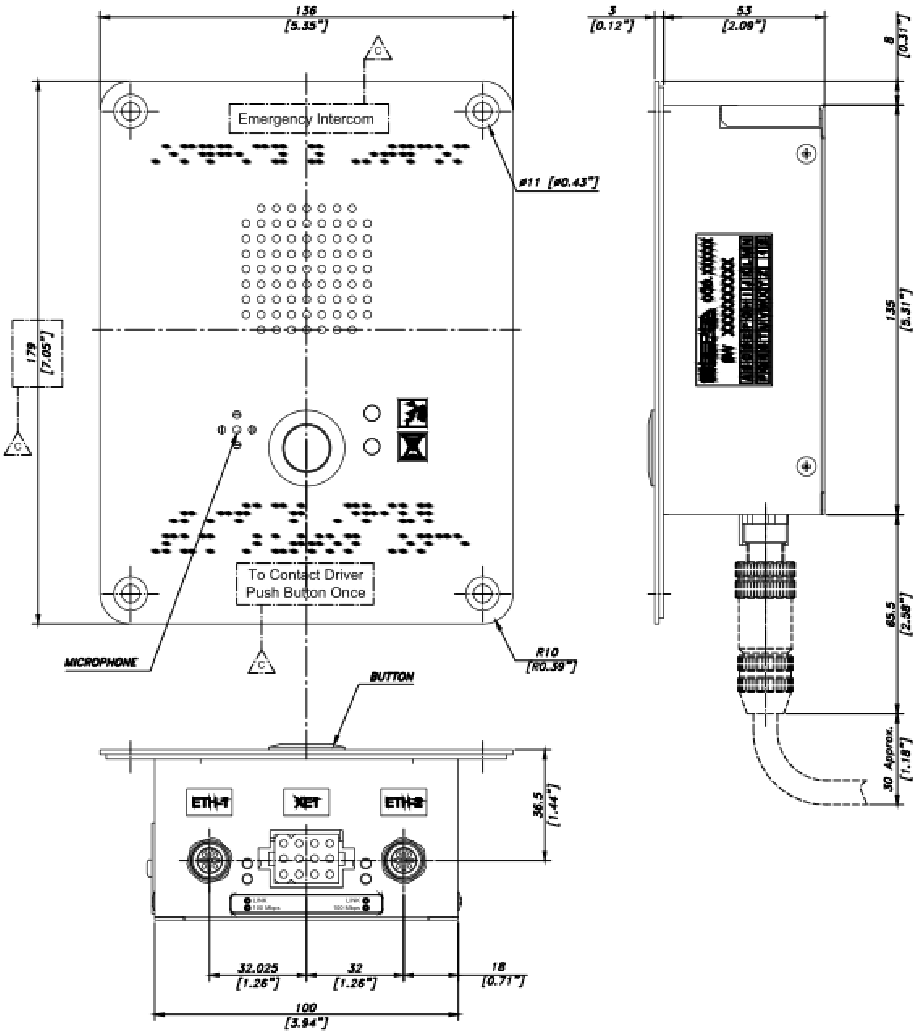
9.11.5.- **USER INTERFACES**

The only user interface is the LED matrix display itself, showing the result

of the orders received from the PIS CPU.

9.12.- INTERCOM

9.12.1.- DESCRIPTION



Drawing 6 - Intercom

The Intercom is responsible, together with the PIS CPU and the Audio Matrix, for establishing a two-way, half-duplex, Driver-Passenger communication.

The passenger can make a call request by pressing the push-button on the front of the intercom, which notify the PIS CPU through the Ethernet status variables. A ringing tone is played by the embedded speaker while the intercom is not being acknowledged by the driver, the red LED in the front is turned on and off, blinking.

The PIS CPU then can establish the connection depending on the driver's input on the ACH. The connection is half-duplex, and the direction is

controlled at any time by the PIS CPU.

The audio is sent from/to the intercom in digital form.

When the driver is speaking, the Audio Matrix converts the analog signal coming from the microphone to digital, and it is sent over Ethernet to the destination Intercom. The Intercom converts the digital audio in analog form, and plays it through its embedded speaker. The LED in the front is turned on, static.

When the passenger is speaking, the Intercom converts the audio in digital form using its embedded microphone and A/D converter, and sends the digitized audio over Ethernet to the Audio Matrix. The green LED in the front is turned on, static.

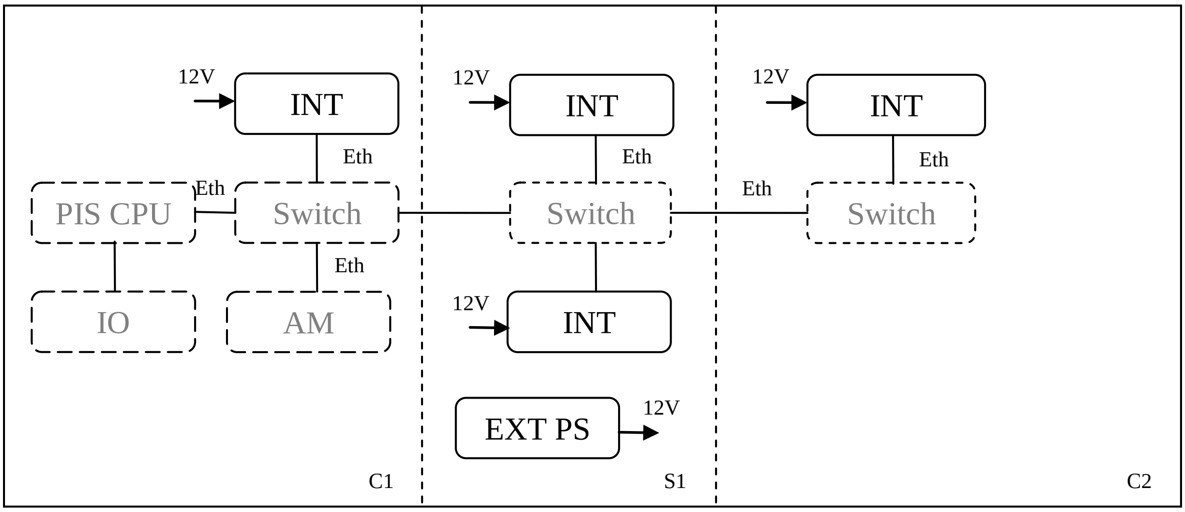


Diagram 8 - Distribution of Intercoms on the Streetcar

All the Intercoms in the Streetcar are powered by 12V DC voltage, generated by the External Power Supply in car S1.

9.12.2.- **HARDWARE OVERVIEW**

The main hardware blocks are the DC-DC converter, Control DSP, ADC converter, digital I/O interface, audio interface and Ethernet Interface.

- The DC-DC converter generates, from the input 12V voltage, all the voltage levels needed by the integrated circuits on the board.
- The Control DSP runs the firmware of the Intercom subsystem, processing the orders from the PIS CPU, process the audio received in digital form from the ADC converter and routes it to destination.
- The ADC converter performs analog-to-digital conversion from the microphone to the Control DSP and digital-to-analog conversion from the Control-DSP to the speaker.

- The audio interface is composed by the embedded microphone and speaker.
- The I/O interface controls the LEDs on the front of the Intercom and reads the activation inputs.
- The Ethernet Interface is the only communication interface of the Intercom with the rest of the PC System.

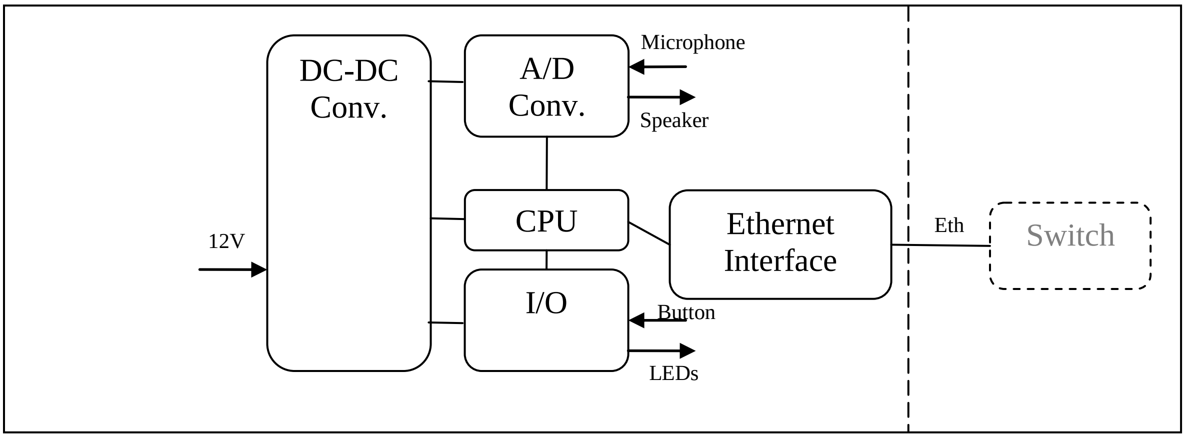


Diagram 9 - Hardware overview of the Intercom

9.12.3.- SOFTWARE OVERVIEW

The software for the EFD is composed of four different products:

- Kernel
- Root File System
- Application
- Configuration

The Kernel and Root File System contain the basic Linux distribution on which the main application runs.

The Application contains the main control logic and interface implementation.

The Configuration contains internal parameters read by the application at runtime.

All products can be updated via Ethernet, using a proprietary application to be run under Windows.

Once the application software has started, the Intercom asks for an ip address which is given by the DHCP server running on the PIS CPU.

The Intercom is identified by the port on the switch it is connected to, and is given a unique DNS name.

Once integrated in the SEPSA's Network the Intercom starts sending status variables to the PIS CPU and receiving the same in return.

At the same time it monitors if the push-button has been pressed, and in this case update its status to the PIS CPU.

When a connection is established, the Control DSP routes the digitized audio either to or from the A/D converter, depending on the direction of the communication (sent by the PIS CPU).

At the same time, the status LEDs on the front are updated depending on the current status (pending, speaking, listening).

9.12.4.- COMMUNICATION INTERFACES

Each Intercom is a host on the SEPSA's Train Network, and it is connected to an external Ethernet port of either the Embedded Switch on the C1 car or the 24 ports Switches on the S1 and C2 cars, depending on where it is situated. This is the interface used to communicate with the PIS CPU. The Intercoms listens to the changes in the PIS CPU status and listens to orders.
The DNS name of the Intercom in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `IE01` or `IE02`, depending on its position in the car.

9.12.5.- USER INTERFACES

The Intercom has a push-button on its front, used by the passenger to request a Driver-Passenger communication.

It has two LEDs close to the Ethernet port, to show incoming/outcoming traffic.

Finally it has two LEDs on the front, in order to provide feedback to the passenger about the communication status. Default behavior is :

- Red LED blinking, green LED off: Connection pending.
- Red LED on, green LED off: Connection established, Driver speaking
- Red LED off, green LED on: Connection established, Passenger speaking
- Red LED off, green LED off: Intercom in standby

9.13.- SALOON SPEAKERS

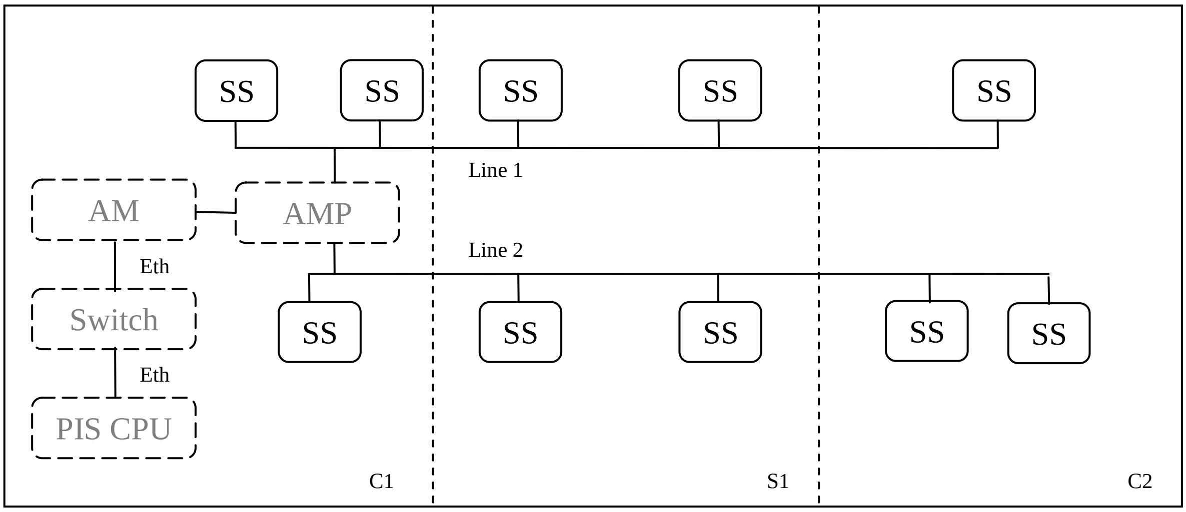


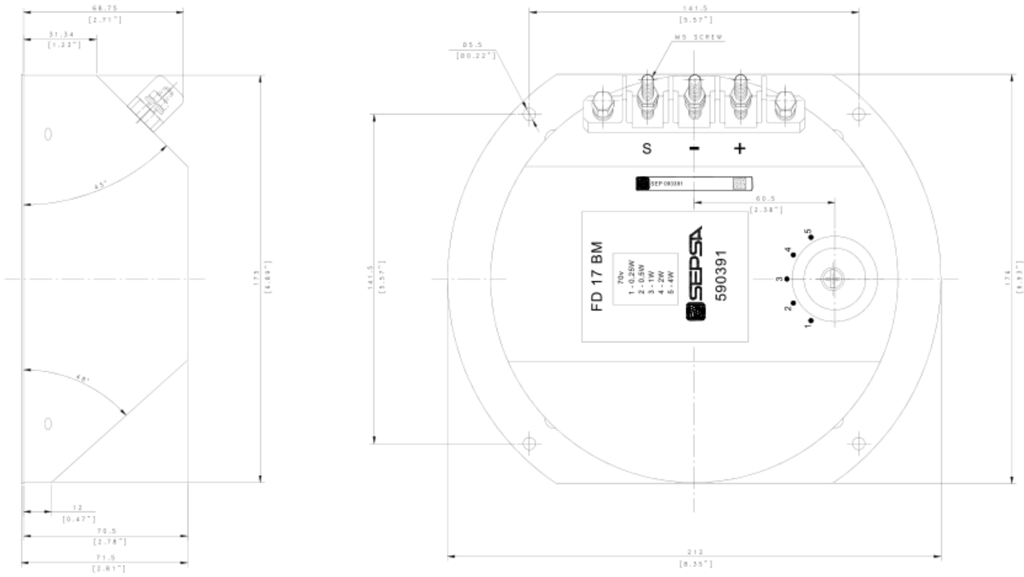
Diagram 10 - Distribution of Saloon Speakers on the Streetcar

9.13.1.- DESCRIPTION

The saloon speakers are the passive devices responsible for the physical audio emission to the public, on the inside of the train's cars. The audio connections that involve saloon speakers are Public Address, Special messages, Announcer messages, Radio-Passengers.

The audio emission orders are generated by the PIS CPU (based on ACH inputs and/or internal logic), routed and converted by the audio matrix and amplified by the AMP board in the control unit, which generates the audio signal finally emitted by the speakers.

The AMP board has two separate outputs for Saloon Speakers, which allow for a distribution of the speakers that is redundant, so that if one line fails there is still audio being played in the car.



Drawing 7 - Saloon Speakers

9.13.2.- **HARDWARE DESCRIPTION**

The actual speaker come mounted in a protective box, and the assembly includes a transformer for impedance matching.

The matching transformer allows the power to be delivered to loudspeakers to be 4/2/0/0.5/0.25W, from the 70V line.

Mean sound pressure level provided is 95dB, with a response ranging from 89dB-100dB in the 300Hz -8KHz frequency range.

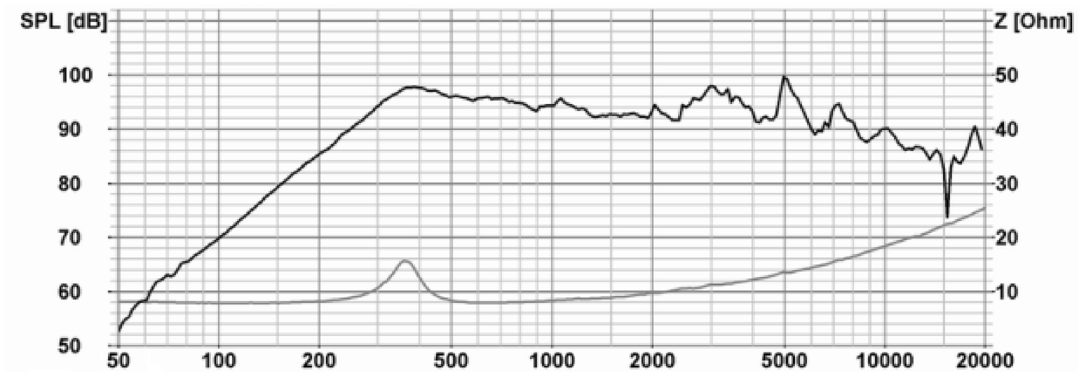


Image 3 - Frequency Response of the Saloon Speakers

9.13.3.- **COMMUNICATION INTERFACES**

The speakers receive the amplified audio signals through two (shielded) signal wires.

9.13.4.- **USER INTERFACES**

On the back of the speaker, there is a knob with five settings: it can be used to adjust the power drawn from the line with the values: 4/2/0/0.5/0.25W

9.14.- CAB SPEAKERS

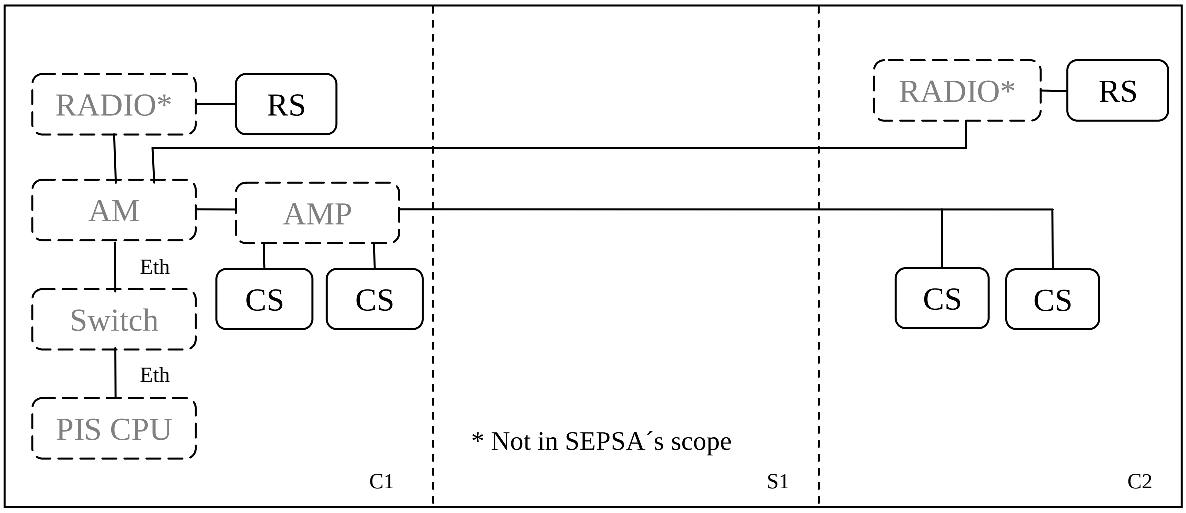


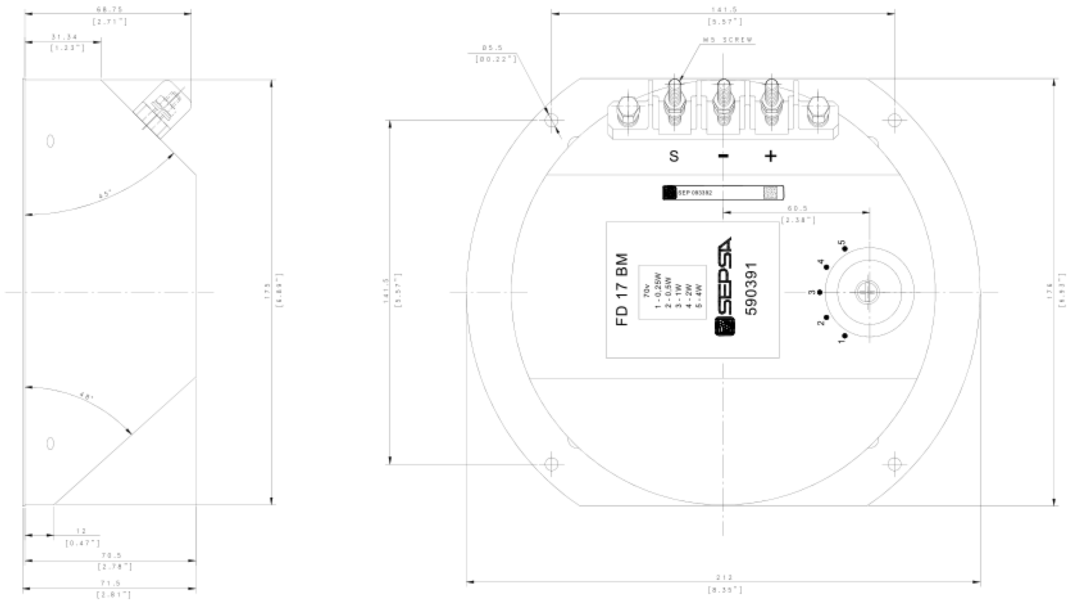
Diagram 11 - Cab Speakers distribution on the Streetcar

9.14.1.- **DESCRIPTION**

The cab speakers are the passive devices responsible for the physical audio emission to the driver. The audio connections involving Cab speakers are Cab-to-Cab and Cab-to-Intercom (with the passenger speaking).

The audio emission orders are generated by the PIS CPU (based on ACH inputs and/or internal logic), routed and converted by the audio matrix and amplified by the AMP board in the control unit, which generates the audio signal finally emitted by the speakers.

The AMP board has two separate outputs for each couple of cab speakers.



Drawing 8 - Cab Speakers

9.14.2.- HARDWARE DESCRIPTION

The actual speaker come mounted in a protective box. The speaker is technically identical to the saloon speaker, but without an impedance matching transformer and power adjustment selector.

Mean sound pressure level provided is 95dB, with a response ranging from 89dB-100dB in the 300Hz -8KHz frequency range.

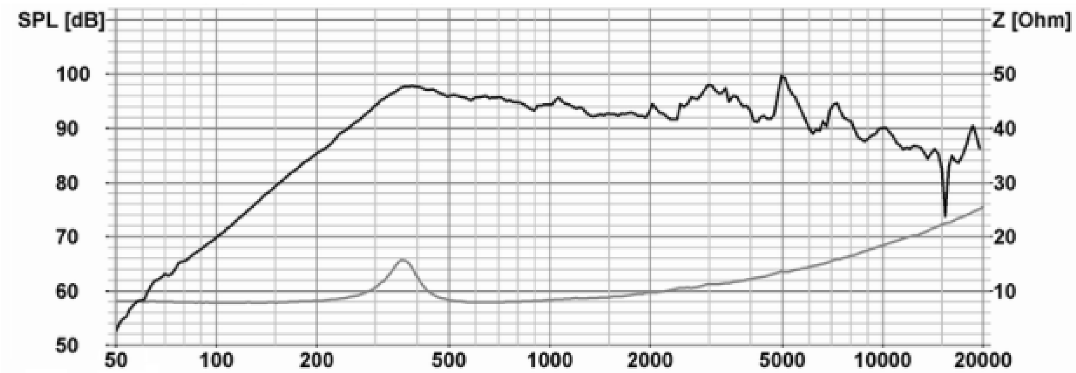


Image 4 - Cab Speakers frequency response

9.14.3.- COMMUNICATION INTERFACES

The speakers receive the amplified audio signals through two (shielded) signal wires.

9.15.- EXTERNAL SPEAKERS

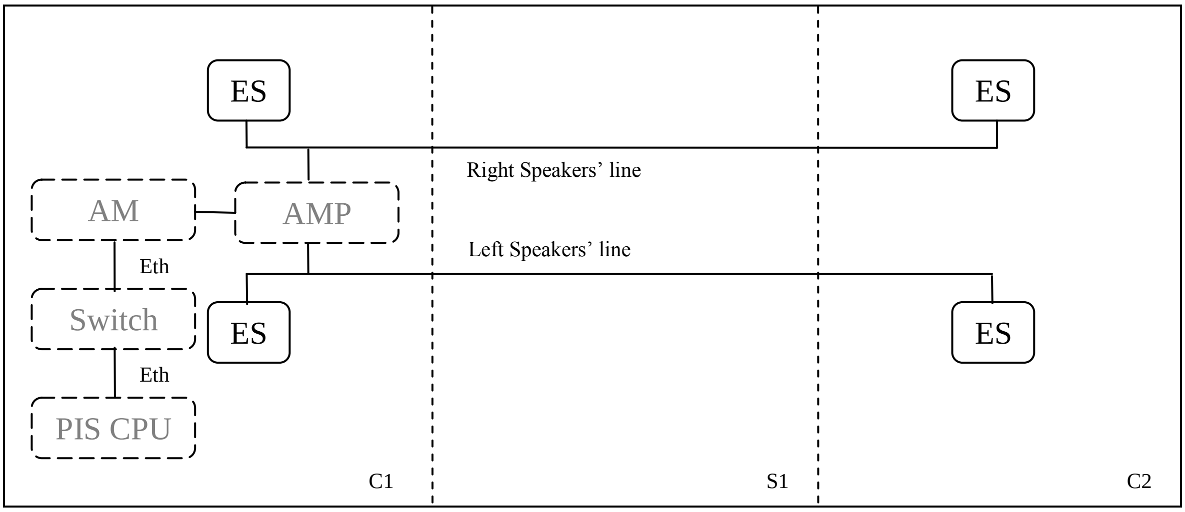


Diagram 12 - External Speakers distribution on the Streetcar

The external speakers are the passive devices responsible for the physical audio emission to the public on the platform. The audio connections that involve external speakers are Public Address, Special messages, Announcer messages, Radio-Passengers.

The audio emission orders are generated by the PIS CPU (based on ACH inputs and/or internal logic), routed and converted by the audio matrix and amplified by the AMP board in the control unit, which generates the audio signal finally emitted by the speakers.

The AMP board has two separate outputs for External Speakers, one for the speakers situated on the right side of the cars and another for the speakers on the left.

The two outputs can be controlled separately using inputs from the ACH.

9.15.1.- **HARDWARE DESCRIPTION**

Image 5 - External Speaker sample unit

The actual speaker come mounted in a protective box, and the assembly includes a transformer for impedance matching.

The matching transformer allows the power to be delivered to loudspeakers to 8/4/2/1/0.5W from a 70.7V line.

These speaker provide a maximum sound pressure level (at 1m) of 109 dB, in the 520-4300Hz range, with the following frequency response :

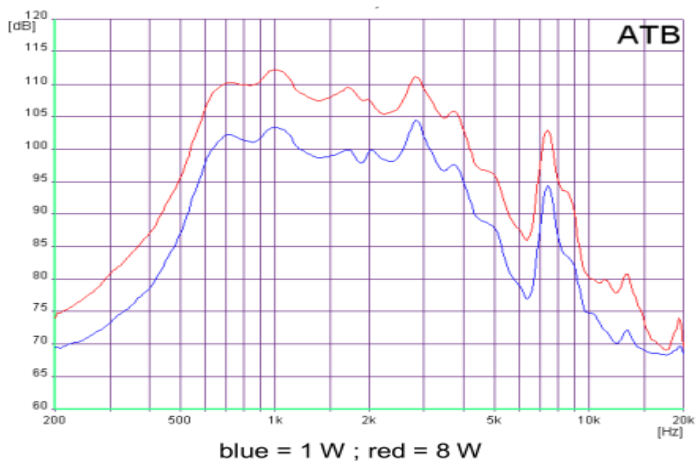


Image 6 - External Speakers frequency response

9.15.2.- **COMMUNICATION INTERFACES**

The speakers receive the amplified audio signals through two (shielded) signal wires.

9.15.3.- **USER INTERFACES**

On the back of the speaker, there is a knob with five settings: it can be used to adjust the power drawn from the line with the values: 8/4/2/1/0.5W.

9.16.- CAB MICROPHONE AND PRE-AMPLIFIER

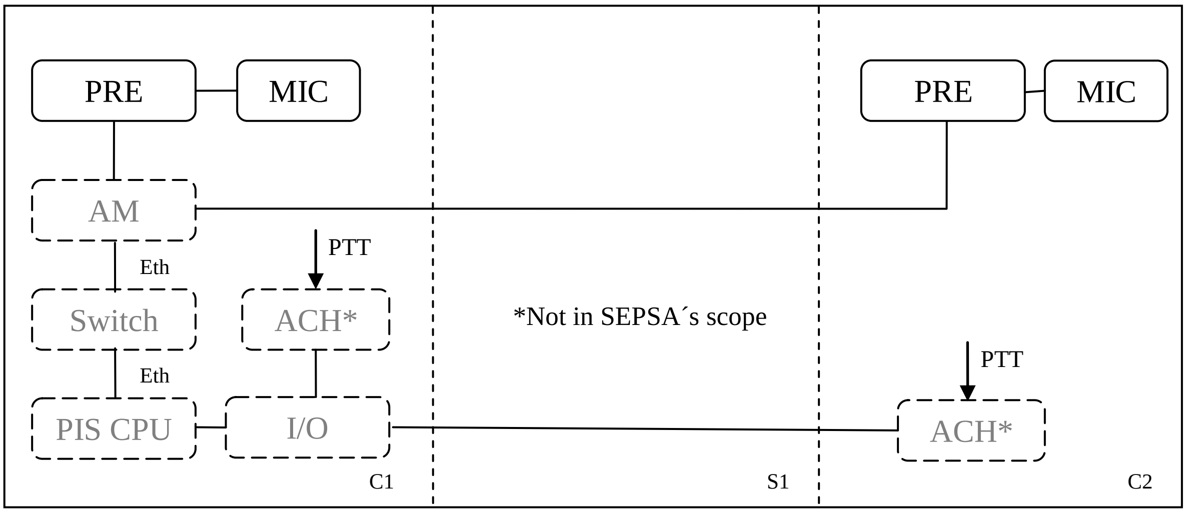


Diagram 13 - Cab Microphone distribution on the Streetcar

9.16.1.- **DESCRIPTION**

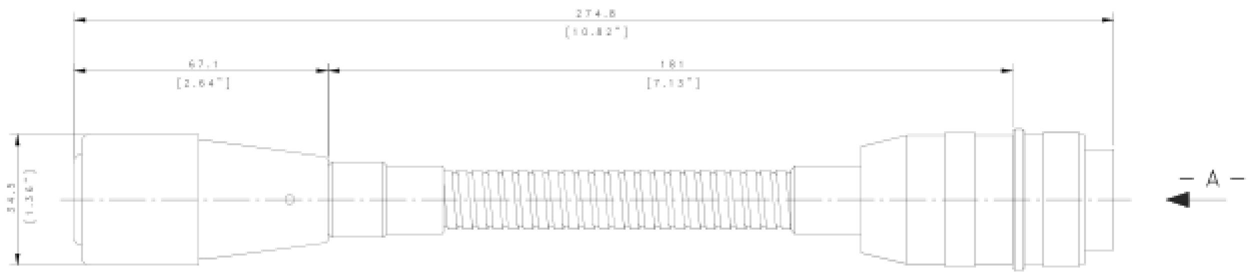
The Cab microphone is the peripheral used by the driver to speak to the passengers in the PA and Cab-Intercom connections and to another staff member in the Cab-Cab connection.

The microphone converts the audio waves emitted by the speaker´s voice into electric signals that can be processed by the System´s audio devices. The pre-amplifier is used to convert the weak signal sampled by the microphone to a level suitable for further processing.

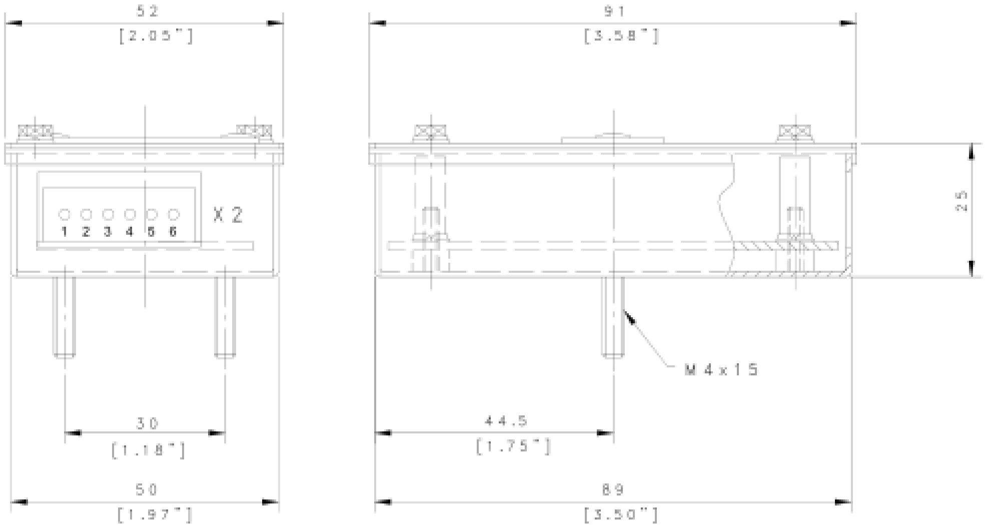
The pre-amplifier output is an input for the Audio Matrix board. When a connection involving the driver is selected and activated, the microphone is turned on by pressing the Push To Talk button on the ACH.

The microphone is enclosed in the flexible gooseneck microphone mount, which will be attached to the ACH.

The pre-amplifier is powered by 12Vdc level voltage generated from the embedded power supply of the CU.



Drawing 9 - Cab Microphone



Drawing 10 - Cab Microphone Pre--amplifier

9.16.2.- HARDWARE DESCRIPTION

The microphone is adapted from a commercial product by Shure, Model 561.

It is a rugged, omnidirectional, dynamic microphone, developed specifically for speech/PA applications.

Frequency response is as follows:

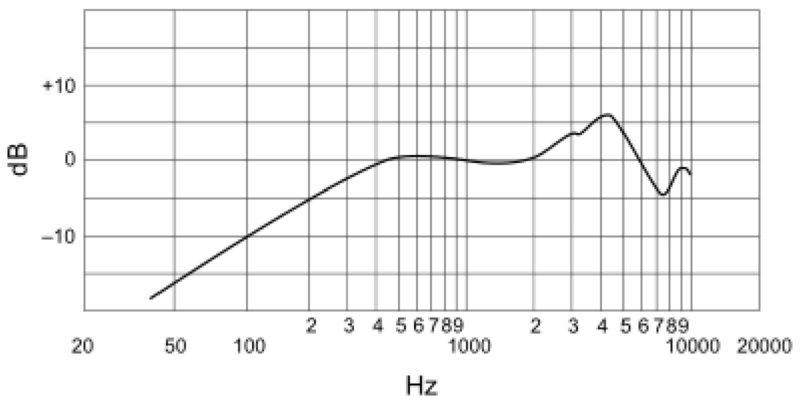


Image 7 - Cab Microphone frequecny response

The pre-amplifier is made up of a DC-DC voltage converter block and the actual amplification block.

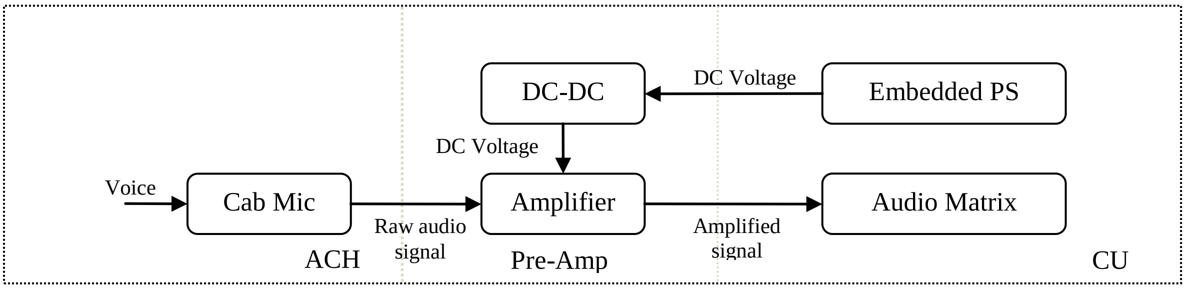


Diagram 14 - Cab Microphone and Pre-amplifier hardware overview

The amplification block applies a low-pass filter and amplifies the signal to the levels expected by the Audio Matrix.

9.16.3.- **COMMUNICATION INTERFACES**

The pre-amplifier is connected to the Audio Matrix in the central unit with two wires arranged in a twisted pair configuration, carrying the audio signal.

9.17.- COVERT MICROPHONE

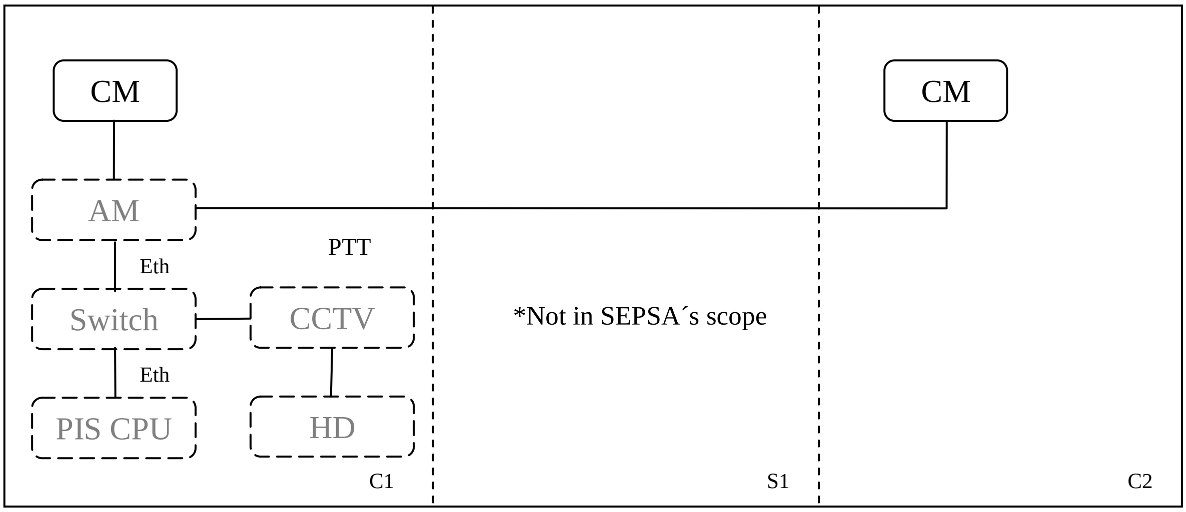


Diagram 15 - Covert Microphone hardware overview

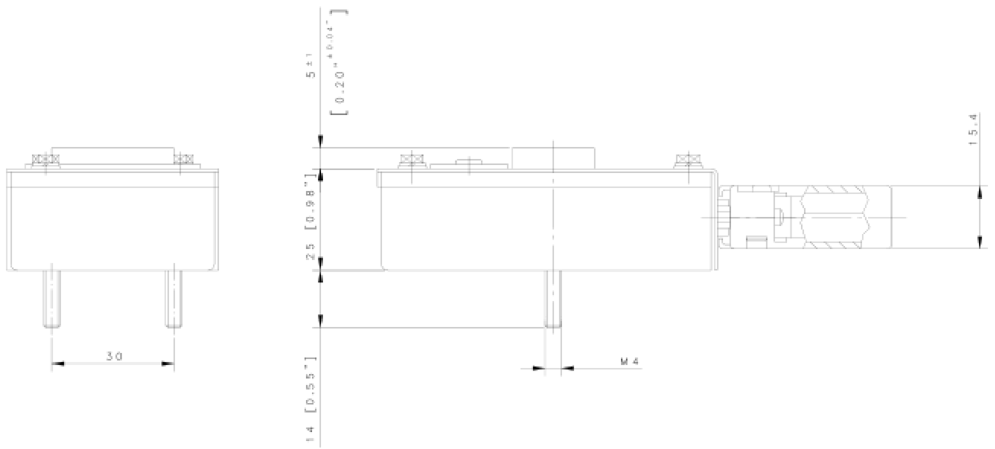
9.17.1.- DESCRIPTION

The Covert Microphone assembly embeds both a microphone and a pre-amplifier.

Its function is to record at any time the sound in the Cab environment, so that the CCTV part of the System can store it as audio files for security purposes.

The microphone converts the audio waves into electric signals that can be processed by the System´s audio devices. The embedded pre-amplifier is used to convert the weak signal sampled by the microphone to a level suitable for further processing.

The pre-amplifier output is an input for the Audio Matrix board. The Audio Matrix digitizes the audio, and sends the resulting audio stream, via Ethernet, to the SVV board.



Drawing 11 - Covert Microphone

9.17.2.- HARDWARE OVERVIEW

The covert microphone design is similar to that of the Cab Microphone and pre-amplifer, with the difference that the microphone is embedded in the main assembly.

The microphone is manufactured by BSE, model CMT-760. It is a omnidirectional, foil electret condenser microphone.

Frequency response is as follows:

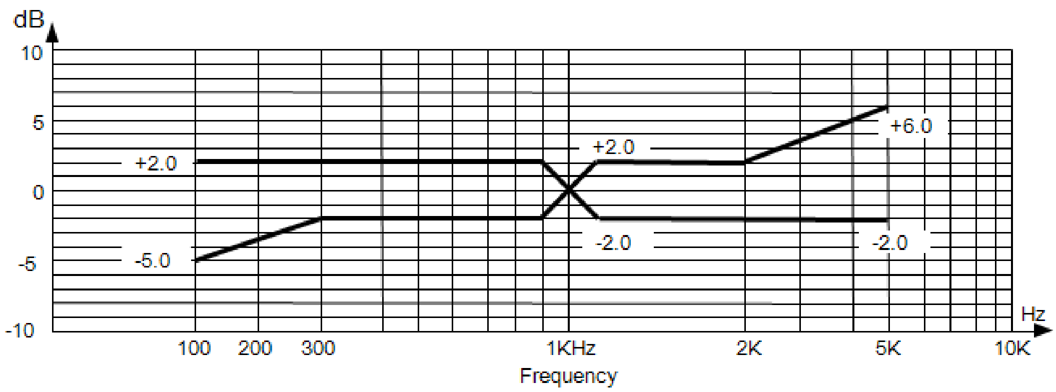


Image 8 - Covert Microphone Frequency response

The pre-amplifier is made up of a DC-DC voltage converter block and the actual amplification block.

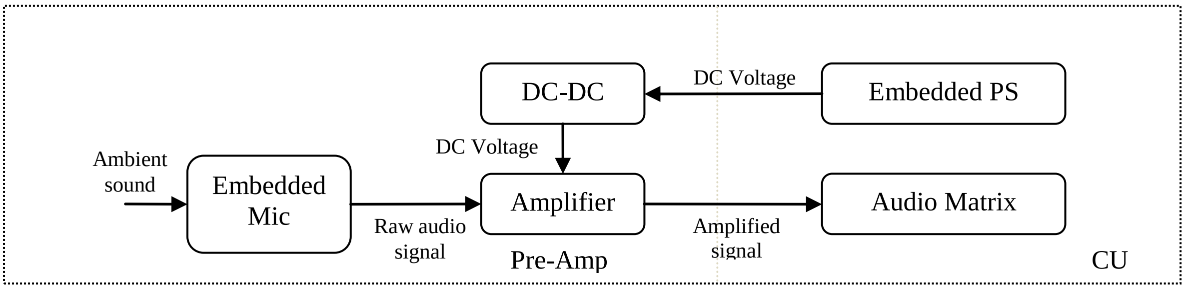


Diagram 16 - Cover Microphone hardware overview

The amplification block applies a low-pass filter and amplifies the signal to the levels expected by the Audio Matrix.

9.17.3.- **COMMUNICATION INTERFACES**

N/A

9.17.4.- **USER INTERFACES**

N/A

10.- VIDEO SURVEILLANCE (CCTV) SYSTEM

The CCTV system is composed of a network of cameras and the intelligence that controls them. The video streams generated by the cameras are recorded and saved on non-volatile memory for security purposes. The CCTV system provides 2 TeraBytes of recording capacity.

The saved videos can be viewed at a later time by using the provided web interface, accesible by connecting a laptop to the maintenance port of the System.

The CCTV has a main intelligence block, running on the SVV CPU in the central unit, a storage unit, and the actual cameras. The CCTV system is tightly integrated with the PIS/PA, so although the CCTV functionalities are managed by the SVV board, this in turn depends on the PIS CPU in order to function properly.

In addition, the CCTV system plays in real-time the stream received from the rearview cameras on the cab monitors, serving as rearview mirrors.

The distribution of the various devices involved in the CCTV functions on the train is the following:

Devices	C1	S1	C2
SVV CPU (CU)	1	0	0
SVV HD (CU)	1	0	0
Frontal Camera	2	0	2
Rearview Camera	2	0	2
Internal Camera	1	2	1
Rearview Cab Monitor	2	0	2

Table 3 - Distribution of CCTV devices on the Streetcar

10.1.- SVV CPU BOARD

10.1.1.- DESCRIPTION

The SVV CPU contains the main control logic of the CCTV system. This board provides the following functionality:

- Provides an interface with the rest of the System by communicating with the main PIS CPU. It reports its own functional status, and that of the Hard Disk and Cameras it manages.
- Subscribes to the streams of the managed cameras, and save those streams in video files, labeling them so that can be easily recovered at a later time.
- Controls the Hard Disk on the HDD board, by formatting it, and managing saved video files, according to the space available and the type of files saved.
- Provides different modes of recording the video stream (normal and alarm)
- Provides a graphical web interface for the retrieval and download of saved video files.

10.1.2.- COMMUNICATION INTERFACES

- The CPU is a host on the SEPSA's Train Network, it's connected to a single Ethernet port of the first Embedded Switch board through the backplane of the CU. This is the main communication interface with the PIS CPU and the Cameras (part of the CCTV subsystem). The DNS name of the CPU in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM token is `SVV01`.
- The CPU are connected to the Power Supply board through the backplane of the CPU.
- The CPU is connected to a twin Hard Disk board, through a SATA cable. The connection allows for data transfer and control logic.

10.1.3.- USER INTERFACES

- The SVV CPU has two set of LEDs on its front. The first group,

labeled L1, L2, L3, L4 shows information over the status of the system. The second group shows information about the status of two Ethernet interfaces (of which only one is used in this project). For complete description of the LED functionality please refer to the User Manual.

- By connecting the maintenance laptop to the SEPSA's Train Network, and accessing the SVV board through its IP/DNS address using a web browser it's possible to access the Web Application that allows the user to download the recorded videos. For complete description of the Web Application functionality please refer to the User Manual.

Image 9 - Video Download web application

10.2.- HD BOARD

10.2.1.- **DESCRIPTION**

There is a HD board in the Control Unit that is paired to its twin SVV board.

The main functionality of the HD board is to provide power and mechanical support for the 2TB Hard Disk mounted inside it. The Hard Disk store the video files generated by the SVV board from the streams of the cameras installed on the train.

The Hard Disk are fully managed by the SVV board, which are able to format, monitor, repair and manage the available space according to the defined logic (different modes, FIFO logic).

10.2.2.- **COMMUNICATION INTERFACES**

- The Hard Disk communicate with the paired SVV board through SATA cables. The cables connect each board

- The Hard Disk are powered by the embedded PS of the Control Unit, and are connected to it through the backplane connector.

10.2.3.- **USER INTERFACES**

- The HD CPU has two of LEDs on its front. The first group, labeled L1, L2 show information over the status of the disk. For complete description of the LED functionality please refer to the User Manual.

- A keyhole is embedded in the front of the board. It is supposed to work with the provided key in order to protect the disk from unsafe extraction. For complete description of the key functionality please refer to the User Manual.

10.3.- INTERIOR CAMERA

10.3.1.- **DESCRIPTION**

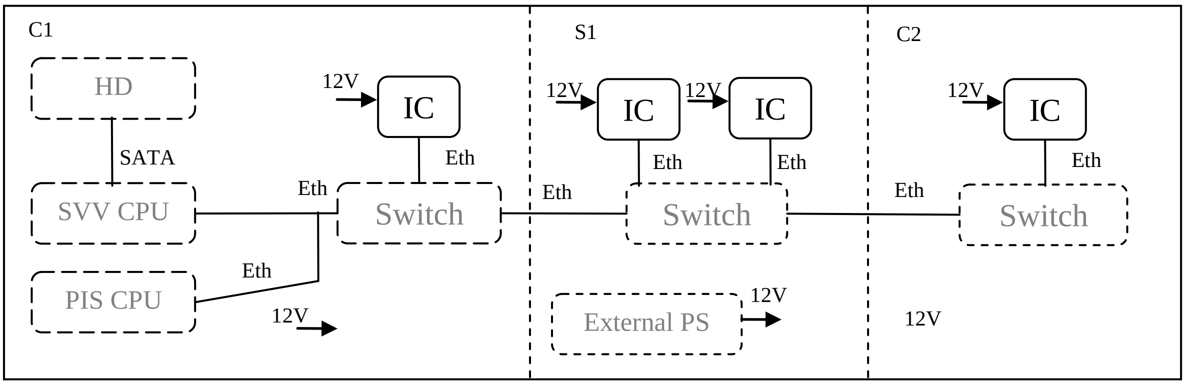


Diagram 17 - Interior Camera distribution on the Streetcar

The interior cameras are placed inside the passengers' cars, in a number and position that allow for total coverage of the environment, and are meant to generate a real-time video stream that the SVV boards can record and store on the Hard Disk.

10.3.2.- HARDWARE OVERVIEW

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Image 10 - Interior Camera sample unit

The System uses commercial cameras from Vivotek, specifically model MD8562D. These models are specifically designed for use in a transportation environment, and provide an ample temperature range, compliance with railway EN50155 normative and a rugged design.

Its main technical features are:

- Streaming video in H.264 format at 30 fps with 1.3 MP (1280 x 1024) resolution.
- Temperature range -25/55° C (EN50155 T3 grade).
- View Angles :
  - Horizontal 110 °
  - Vertical 81.5°
  - Diagonal 142 °
- Wide Dynamic Range capabilities to deal with extreme lighting conditions.

10.3.3.- SOFTWARE OVERVIEW

The cameras are commercial product and run their own firmware. They interact with the System through standard network protocols.

When they are powered up, they ask an ip address through the DHCP protocol, with the PIS CPU acts as the DHCP server.

Once the camera finishes booting, it will publish its video stream in H.264 format using RTSP protocol over multicast.

One of SVVs CPUs has subscribed to the stream and it will store it in the managed HD.

10.3.4.- **COMMUNICATION INTERFACES**

- The cameras are hosts on the SEPSA's Train Network, and they are connected to individual external ports of SEPSA's Switches. This is the main communication interface with both the PIS CPU and the SVV CPU. The DNS name of the cameras in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM tokens are `ICXX`, with XX either `01` or `02`, depending on the camera's position.

- The cameras are powered by SEPSA's External Power supply in car S1.

10.4.- FRONTAL CAMERA

10.4.1.- **DESCRIPTION**

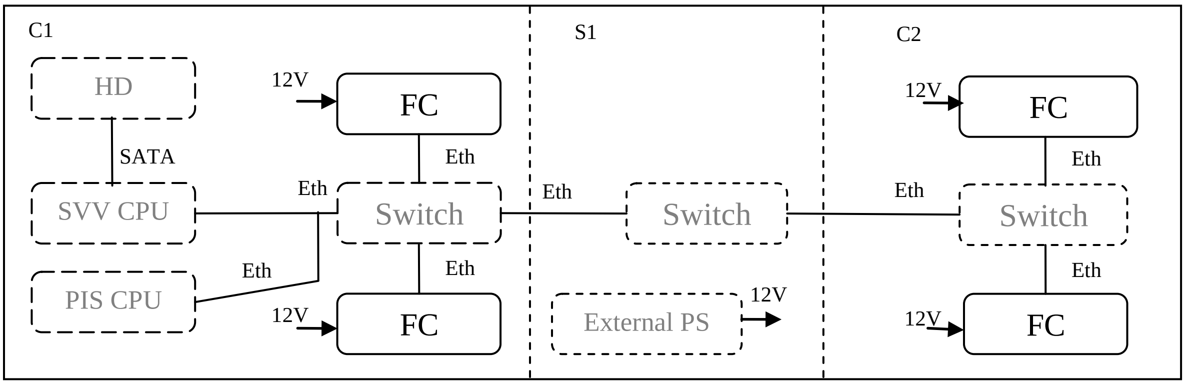


Diagram 18 - Distribution of Frontal Cameras on the Streetcar

Two frontal cameras are placed inside the driver's cab, in a number and position that allow for total coverage of both the road and the signs on the roadsides in front of the Streetcar.

10.4.2.- HARDWARE OVERVIEW

Image 11 – Frontal Camera sample unit

Two frontal cameras are placed inside the driver's cab, in a number and position that allow for total coverage of both the road and the signs on the roadsides in front of the Streetcar.

The System uses commercial cameras from Vivotek, specifically model IP8352. These models are specifically designed for use in a transportation environment, and provide an ample temperature range

Its main technical features are:

- Streaming video in H.264 format at 30 fps with 1.3 MP (1280 x 1024) resolution.
- Temperature range -25/55° C (EN50155 T3 grade).
- View Angles :
    - Horizontal 85.7° ~ 31.46°
    - Vertical 73.16° ~ 31.46°
    - Diagonal 99.82° ~ 39.67°
    - Auto Iris, in order to deal with sudden lighting changes

10.4.3.- SOFTWARE OVERVIEW

The cameras are commercial product and run their own firmware. They interact with the System through standard network protocols.

When they are powered up, they ask an ip address through the DHCP protocol, with the PIS CPU acts as the DHCP server.

Once the camera finishes booting, it will publish its video stream in H.264 format using RTSP protocol over multicast.

One of SVVs CPUs has subscribed to the stream and it will store it in the managed HD.

10.4.4.- **COMMUNICATION INTERFACES**

- The cameras are hosts on the SEPSA's Train Network, and they are connected to individual external ports of SEPSA's Switches. This is the main communication interface with both the PIS CPU and the SVV CPU. The DNS name of the cameras in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM tokens are `FCXX`, with XX either `01` or `02`, depending on the camera's position.

- The cameras are powered by SEPSA's External Power supply in car S1.

10.5.- REARVIEW CAMERA

10.5.1.- **DESCRIPTION**

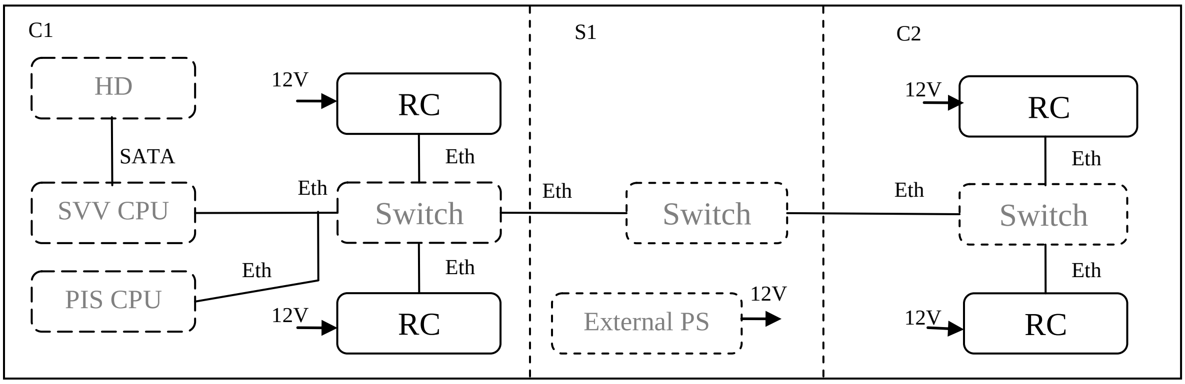


Diagram 19 - Distribution of Rearview Cameras on the Streetcar

A rearview camera is placed on both sides of each cab car, and provides full coverage of the Streetcar's doors. Its stream is shown in real time in the Cab Monitor, providing rearview mirror functionality, in addition to being recorded and stored in the SVV Hard Disk, for security purposes.

The rearview cameras will be placed in a protective enclosure (out of SEPSA's scope, to be provided by CAF), for which the cameras have been selected to be mechanically compatible.

10.5.2.- **HARDWARE OVERVIEW**

Image 12 - Rearview Camera sample unit

The System uses commercial cameras from Vivotek, specifically model MD8562D. These models are specifically designed for use in a transportation environment, and provide an ample temperature range, compliance with railway EN50155 normative and a rugged design.

Its main technical features are:

- Streaming video in H.264 format at 30 fps with 1.3 MP (1280 x 1024) resolution.
- Temperature range -25/55° C (EN50155 T3 grade).
- View Angles :
    - Horizontal 110 °
    - Vertical 81.5°
    - Diagonal 142 °
- Wide Dynamic Range capabilities to deal with extreme lighting conditions.

10.5.3.- SOFTWARE OVERVIEW

The cameras are commercial product and run their own firmware. They interact with the System through standard network protocols.

When they are powered up, they ask an ip address through the DHCP protocol, with the PIS CPU acts as the DHCP server.

Once the camera finishes booting, it will publish its video stream in H.264 format using RTSP protocol over multicast.

One of SVVs CPUs has subscribed to the stream and it will store it in the manage HD.

In addition, also the Cab monitor subscribes to the same stream, and shows the video in real-time.

Using multicast to publish the stream allows the System to use less bandwidth.

10.5.4.- **COMMUNICATION INTERFACES**

- The cameras are hosts on the SEPSA's Train Network, and they are connected to individual external ports of SEPSA's Switches. This is the main communication interface with both the PIS CPU and the SVV CPU. The DNS name of the cameras in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM tokens are `RCXX`, with XX either `01` or `02`, depending on the camera's position.

- The cameras are powered by SEPSA's External Power supply in car S1.

10.6.- REARVIEW MONITOR 9" TFT

10.6.1.- **DESCRIPTION**

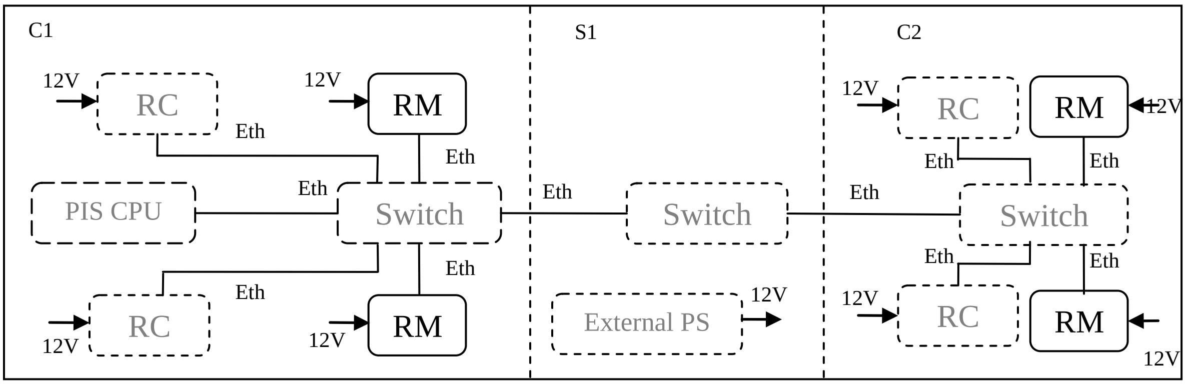


Diagram 20 - Rearview Monitor Distribution on the Streetcar

The Rearview Monitors provide rearview mirror functionality to the driver.

There are two monitors in each cab, to be installed on either side of the driver's console, so that the longest sides of the screen are the vertical ones.

The monitors subscribe to the Rearview Cameras video stream, and visualize it in real time on their screen.

By default, each monitor will show the stream of two cameras at the same time, so that both monitors will be able to show the streams of all the Rearview Cameras installed.

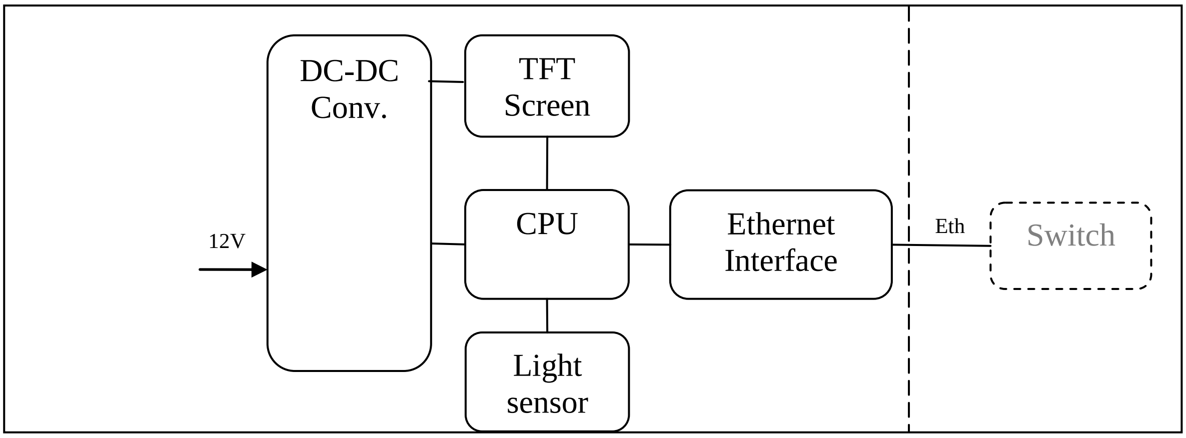
The information of which cameras to show in which quadrant will be

decided at runtime by the Cosmos, published via MVB, and relayed to the Rearview monitor by the PIS CPU.

10.6.2.- HARDWARE OVERVIEW

The main hardware blocks are the DC-DC converter, CPU, and TFT screen.

- The DC-DC converter generates, from the input 12Vdc voltage, all the voltage levels needed by the integrated circuits on the board.
- The CPU is a Cortex-M3 from Freescale, mounted on a Q7 main board. It controls the Ethernet interface and the video output to the TFT screen.
- The TFT screen is the main user interface of the RM, it's a 9" screen capable of a maximum resolution of 800x480 and luminosity of 500Lux.
- A photodiode light sensor is used to detect changes in the lighting conditions, in order to automatically (if so configured) dim or brighten the screen accordingly.



10.6.3.- SOFTWARE OVERVIEW

The software runs over a customized Linux distribution. The underlying operating system provides support for Ethernet communication, logging, watchdog (if the system fails, it is able to reboot and return to a working condition) and functionality.

Once the application software has started, the Rearview Monitor asks for an ip address which is given by the DHCP server running on the PIS CPU.

The Intercom is identified by the port on the switch it is connected to, and is given a unique DNS name.

Once integrated in the SEPSA's Network the Rearview Monitor starts sending status variables to the PIS CPU and receiving the same in return.

The RM then subscribes to the multicast video stream of all the rearview cameras on the train.

The PIS CPU monitors the MVB port dedicated to camera visualization, and generates commands for the RM. Depending on these commands, the RM shows the relevant video stream in the desired quadrants.

The variable exchange is in the form *CameraNumber=Quadrant*, where *CameraNumber*is an absolute identifier of the camera depending on its position on the train (and deduced by the ip address assigned by the DHCP server), while quadrant is a number from 1 to 4 identifying one half of the tft screen between the two RM in the active cab.

This way there is a large flexibility in terms of which video stream is shown where. As per requirements, the initial configuration will have the two left cameras shown on the left screen, and the two right cameras shown on the right screen.

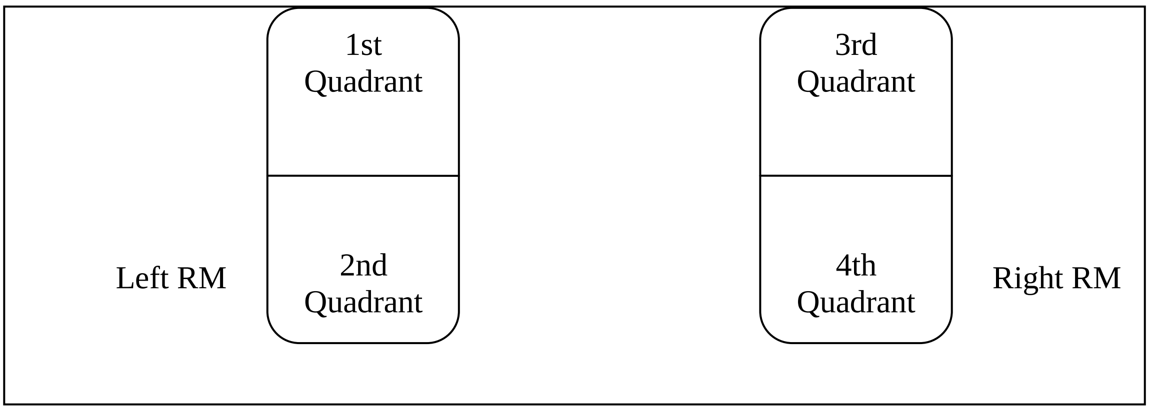
10.6.4.- **COMMUNICATION INTERFACES**

The Rearview Monitors are hosts on the SEPSA's Train Network, and they are connected to individual external ports of SEPSA's Switches. This is the main communication interface with both the PIS CPU and the Rearview Cameras. The DNS name of the Monitor in the Network follows the IP addressing schema outlined in the Ethernet Backbone System part of the document and its SYSTEM tokens are `RMXX`, with XX either `01` or `02`, depending on the Monitor's position.

10.6.5.- **USER INTERFACE**

The only user interface of this subsystem is the TFT screen on which the camera streams are shown.

The screens in the active cabs will be divided into halves as follows:



11.- SUPPORT EQUIPMENT

11.1.- AUDIO RECORDING AND MAINTENANCE UNIT

The audio recording and maintenance unit is a commercial desktop or notebook PC that can be used to record the audio messages and is able to run the database configuration tool of the Automatic Announcement system.

The exact specifications and model are to be defined but the unit will be :

- Commercial Desktop or Notebook PC, currently available on the market, from a known provider (Dell, HP).
- Running Windows 7, or equivalent.
- Equipped with a SD card reader, so that the Database Configuration can be saved for later update on the Train Unit.
- Equipped with a quality sound card and microphone, so that the audio messages for the Announcer can be recorded.
- Equipped with SEPSA's Database Configuration Tool.
- Equipped with an application for recording audio MP3 files, compatible with the format used by the PIS Announcer.

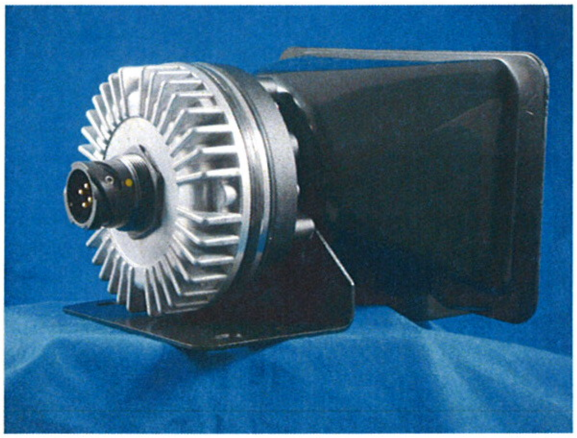
--- END OF DOCUMENT ---

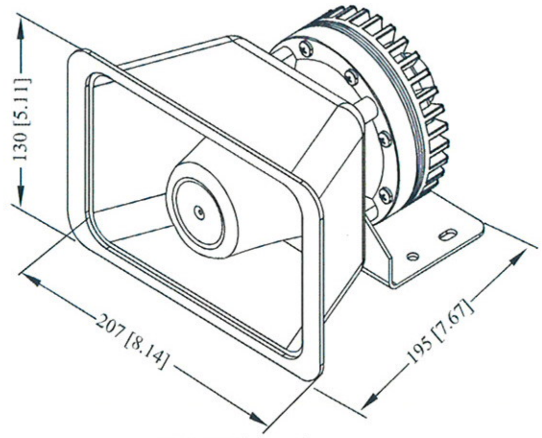
APPENDIX 13.3

DRIVER-HORN TYPE3

VECOM USA

DH-3 — Driver/Horn Type 3





DH-3 Dimensions

Introduction

The Driver/Horn Type-3 is designed to be used in combination with our Train Digital Sound Generator TDSG-200/25. To use the full capabilities of the TDSG-200/25, it is recommended that two (2) DH-3 units be connected in a series to the output of the TDSG-200/25. To withstand extreme external environmental conditions, this unit is IP 67 compliant and, if required, can be delivered with an optional integrated heating element.

Specifications: Driver/Horn Type-3

Power Rating	110 Watt RMS, 150 Watt max. (8 ohm)	
A.C. Impedance	11 ohm	
DCR	4.7 ohm	
Frequency Range	275 ~ 5000 Hz	
Sensitivity	111 dB at 1W/1m	
Horn Coupling	1-3/8"- 18 male thread	
Option	Integrated heating element	
Connector	Spacecraft SCPB07R-18-1-SWF80	
Environment	Temperature	-40 ~ +185 °F (-40 ~ +85 °C), Operating
	Humidity	-95% @ 104 °F (+40 °C) (non condensing), Operating
	Compliant with	EN 50155
Physical Characteristics	Construction	Aluminum
	Finish	Black powder coating chosen for durability, environment stability and anti-corrosion against 240 h salt spray test
	Mounting	Stand alone mounting
	Dimensions (WxHxD)	8.14" x 5.11" x 7.67" (207 x 130 x 195mm)
	Weight	5.2 lb (2.39 kg)

Ordering Information

Part Number	Description
6950 0000 5496	Driver/Horn Type 3 (DH-3)

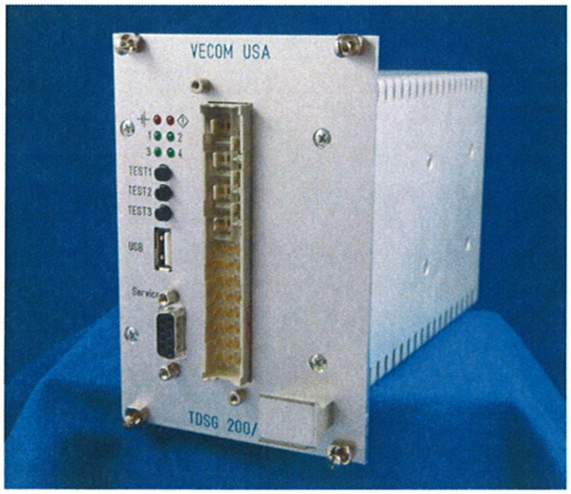
VECOM USA, LLC 4803 George Road, Unit 300, Tampa, FL 33634 Tel: 813-901-5300 Fax: 813-433-2458
Website: www.vecom-usa.com E-mail address: Info@vecom-usa.com

APPENDIX 13.4

TDSG 200-25

VECOM USA

TDSG-200/25 — Train Digital Sound Generator 200/25



Features

- Federal Transportation Administration compliant
- Up to 16 different sounds or tones are available
- 125 dB at a 4 foot distance
- Any sound or tone can be produced
- Two Class-D Amplifiers, one for exterior horns and one for interior digital announcements and/or interior tones
- Traffic and passengers can be warned of dangerous situatons when the vehicle is approaching and/or leaving a stop
- Traffic and pedestrians can be warned at crossing intersections

Introduction

The Train Digital Sound Generator 200/25 (TDSG 200/25) provides automatic exterior and simultanious interior digital announcements, sounds and tones for public transportation vehicles. The system consists of a Controller/Amplifier Unit which is mounted inside the vehicle and an exterior/interior speaker system. The exterior speaker system consists of one or two professional audio drivers and horns. To withstand extreme external environmental conditions, the exterior speaker system housing is IP67 compliant and is customized to your specification. The interior speaker system can be an existing system or additional speakers mounted at specific locations inside the vehicle depending upon the required functionality, i.e., near the doors to trigger a door obstruction.

Manual Operation

The vehicle operator can initiate announcements, sounds and tones manually by activating relevant pushbuttons on the dashboard of the cab.

Standard System Functions

- Any sequence of sounds mandated by the Federal Transportation Administration can be configured.
- Announcements, sounds and tones can be initiated automatically by external input signals from the vehicle wiring.
- The volume of announcements, sounds and tones can be configured for time-of-day segments using an integrated real-time clock.
- High and Low Priority, etc.

Service Tools

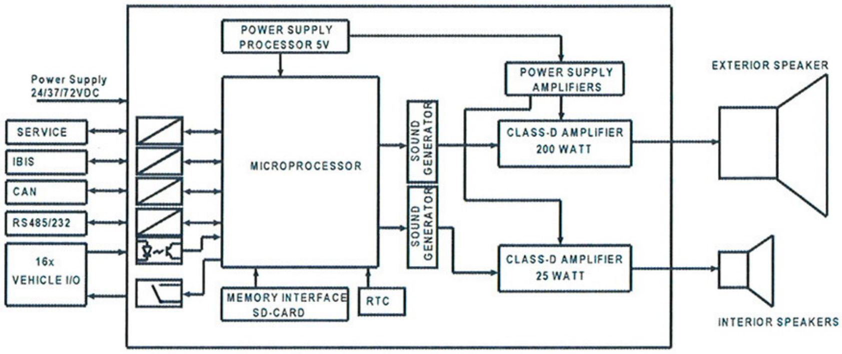
- Three pushbuttons on the front of the Controller/Amplifier Unit are used for initiating test procedures.
- Four LEDs on the front of the Controller/Amplifier Unit display the system status.
- An optional, user-friendly software application is available for configuration and testing purposes.

Database Management

No special software is required for maintaining and/or upgrading the internal digitally-compressed MP3 files database. A customer-provided standard PC with USB interface and a standard audio management software application may be used for this purpose. This enables the user to make their own or studio produced announcements, sounds and tones. The internal memory of the Controller/Amplifier Unit can be loaded from a PC through the USB interface.

VECOM USA

TDSG-200/25



Block Diagram TDSG-200/25

Specifications: Controller/Amplifier Unit

Power Amplifier 1	Class-D 200 W at 8 Ohm	
Loudness at 4ft distance	125 dB	
Test Results	High Horn: 102 dB at 30m distance, Low Horn: 96 dB at 30m distance and Bell: 92 dB at 15m distance.	
Power Amplifier 2	Class-D 25 W at 8 Ohm	
Audio Bandwidth	20 ~ 15 kHz	
Audio Compression	MP3	
Microprocessor	M32C/84 - 512 KB Flash	
Serial Interface	Standard RS232, Optional IBIS, CAN and RS485 (TCP/IP in development)	
Vehicle Interface	16 Opto-Coupler inputs	
Internal Memory	Standard 256 MB SD-Card, Optional 2GB Max.	
SD-Card Interface	Standard Internal, Optional External Download Slot	
Internal Clock Retention	~ 10 days without external Power	
Power Requirements	Power Consumption	24 VDC 8 Amp
	Input Voltage	16.8 ~ 47 VDC, Optional 72 VDC
Environment	Temperature	-40 ~ +185 °F (-40 ~ +85 °C), Operating
	Humidity	-95% @ 104 °F (+40 °C) (non condensing), Operating
	Vibration Resistance	1 Grms, IEC 60068-2-64, Random, 5 ~ 500 Hz, 1 Oct/min, 1 hr/axis, Operating
	Shock Resistance	20 G, IEC 60068-2-27, half sine, 11 ms, Operating
Physical Characteristics	Construction	Aluminum housing
	Mounting	Stand alone or 19" rack mounting
	Dimensions (WxHxD)	6.69" x 5.11" x 2.75" (170 x 130 x 70mm))
	Weight	2.4 lb (1.08 kg)

Specifications: Audio Driver

Frequency Response	275 - 5.000 Hz
Sensitivity	113 dB
Power Capacity	110 Watt rms/150 Watt max (8 Ω)
Dimensions	4.9" x 3.9" (125 x 100 mm)

Ordering Information

Part Number	Description
6950 0000 5704	Controller/Amplifier Unit
6950 0000 5363	Audio Driver with Horn type 1
6950 0000 5496	Audio Driver with Horn type 2

Specifications: Horn

Horn type 1	(W x H x D) 14.5" x 6.25" x 9.0" (368 x 158 x 228 mm)
Horn type 2	(W x H x D) 8.25" x 5.25" x 3.75" (208 x 132 x 95 mm)

VECOM USA, LLC 4803 George Road, Unit 300, Tampa, FL 33634 Tel: 813-901-5300 Fax: 813-433-2458
Website: www.vecom-usa.com E-mail address: Info@vecom-usa.com

APPENDIX 13.5

EVENT RECORDER TECHNICAL DESCRIPTION

ISSUE CONTROL

ISSUE	REASON	DATE
-	First issue	19/APR/2013
A	As-built update	20/JAN/2015
B	Correction of wheel teeth data in technical description.	25/MAR/2015

DISTRIBUTION

Miguel Artigas (Technical Project Manager)
Ignacio Olivera (Project Manager)
City of Cincinnati

Prepared by: **Name:** I.Pinilla(CAFTE)/ R. Spinosi (HaslerR. **Signature:** **Date:** 25/Mar/2015	**Revised by:** **Name:** R. Ortega **Signature:** **Date:** 25/Mar/2015	**Approved by:** **Name:** Miguel Artigas **Signature:** **Date:** 25/Mar/2015

INDEX

1 PURPOSE

The purpose of this document is to present, for City of Cincinnati review and approval, the Technical Description of the Event Recorder System of the Cincinnati Streetcar.

2 ATTACHMENTS

Document	Issue	Date	Generated by
Technical Description - Project Cincinnati - TELOC®1500 Event Recorder	F	25.Mar.2015	HaslerRail
Applications for Deviations of product	A00	19.Apr.2013	HaslerRail

ATTACHMENT 1. Technical Description - Project Cincinnati - TELOC®1500 Event Recorder

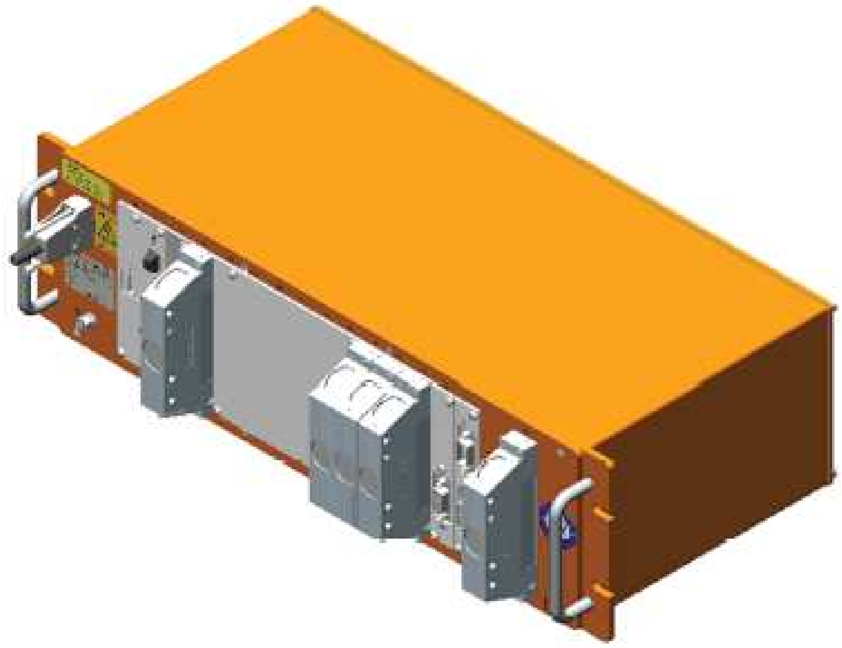
Security Class

EXTERNAL

Technical Description

Project Cincinnati

TELOC®1500 Safety Event Recorder with external black box



Construcciones y Auxiliar de Ferrocarriles

Author	Andy Gonzalez	25.03.15	**TELOC 1500 Cincinnati**		
Revised	Remo Spinosi	25.03.15			
Authorized	Andy Gonzalez	25.03.15		**5.2421.122/01V01**	
Version	**F**				

Version History

Version	Modifications/Comments	Signature	Date
A	Draft edition	Alberto Rakas	01.12.2012
B	Modifications according to CAF comments	Alberto Rakas	14.01.2013
C	Modifications according to CAF comments	Ruedisueli Josef	27.05.2013
D	Actualization after HW defined	Andy Gonzalez	07.10.2013
E	Add new chapter, §5.7.2 Estimated time recorded	Andy Gonzalez	01.12.2014
F	Modification on chapter §5.7.6 teeth value	Remo Spinosi	25.03.2015

Index

INTRODUCTION

1.1 *Purpose*

The purpose of this document is to supply all design and functionality information of the Event Recorder System supplied by HaslerRail to be installed in project Cincinnati trams

1.2 *HaslerRail AG, Switzerland*

Hasler has produced event recorders for rail applications since 1887. Hasler products offer measurement, recording, transmission and evaluation of data with their TELOC® on-board monitoring and recording systems.

Hasler is focused on the design, application development, final assembly, testing, distribution and marketing of event recorders and related equipment. The Hasler brand stands for excellent quality and innovation in the tachometry sector.

For more information visit the website http://www.haslerrail.com

2 CUSTOMER SPECIFICATION

In the frame of the Project Cincinnati, HaslerRail AG was solicited from CAF Spain to quote the Event Recorder unit (EVR) with a external CPM.

The ER will be mounted in a car by CAF.

- The main requirements of the functionalities are resumed as follows:
- 1 recorder per train, with optional protected memory.
- Recording memory for at least the last 7 days
- Measurement from speed sensors and recording of train speed
- 128 digital inputs (32 hard wired digital inputs)
- 80 analogue inputs (6 hard wired analogue inputs)
- 80 outputs (10 hardwired relay outputs, 2 transistor outputs.
- 2 hardwired analogue outputs
- MVB and Hardwired signal recording (digital and analogue)
- (Redundant) MVB EMD class 1 interface to train communication network (TCN)
- Dead-man functionality.
- Recording in external Crash Protected Memory (CPM) according to standard IEEE1482.1 (will be mounted outside from the TELOC)
- Fast data download through USB 2.0 or Ethernet
- SIL2 Speed display (SPEEDO)

According to end customer specifications these above requirements can be varied and adaptations have to be carried out accordingly.

Further in this technical description only the basic functions are described. Project specific technical description will be made according to customer specific requirements during project phase.

3 REFERENCES

		Document ID
[1] System Specification	- Project J0226B	5.2421.122/01N01
[2] Release Note	- Project J0226B	5.2421. 122/01R01
[3] Function Description	- Project J0226B	5.2421. 122/01T01
Hardware manuals:		
[4] TELOC®1500 manual		5.0300.085 EN
Service and evaluation software manuals:		
[5] Hasler®MultiRec-SG guide		5.0300.048 TEN
[6] Hasler®MultiRec-SG install instructions		5.0300.043 TEN
[7] TELOC®EVA manual		5.0300.045 EN

4 DEFINITIONS & ABBREVIATIONS

COREB	Processor board Rev. B
CPM	Crash Protected Memory
DAIOC	Digital and analogue Input board
DAIOC digi	Digital Input board
ER	Event Recorder (synonym for OTMR)
MultiRec-SG	TELOC service software tool
HW	Hardware
IOCOB	Interface board Rev. B
LTM	Long Term Memory
OPM	Operational data Memory
OS	Operating System
OTMR	On train monitoring and recorder
POSUE	Power Supply board Rev. E
PWM	Pulse Width Modulation
REBOB	Relay board Rev. B
STM	Short Term Memory
SW	Software
TDR	Train Data Recorder (synonym for OTMR)
TELOC	Train-borne data recording unit (brand name)
EVA	TELOC data evaluation software tool
SABO	Safety Board
USB	Universal Serial Bus

5 DESIGN PHILOSOPHIE

5.1 *General*

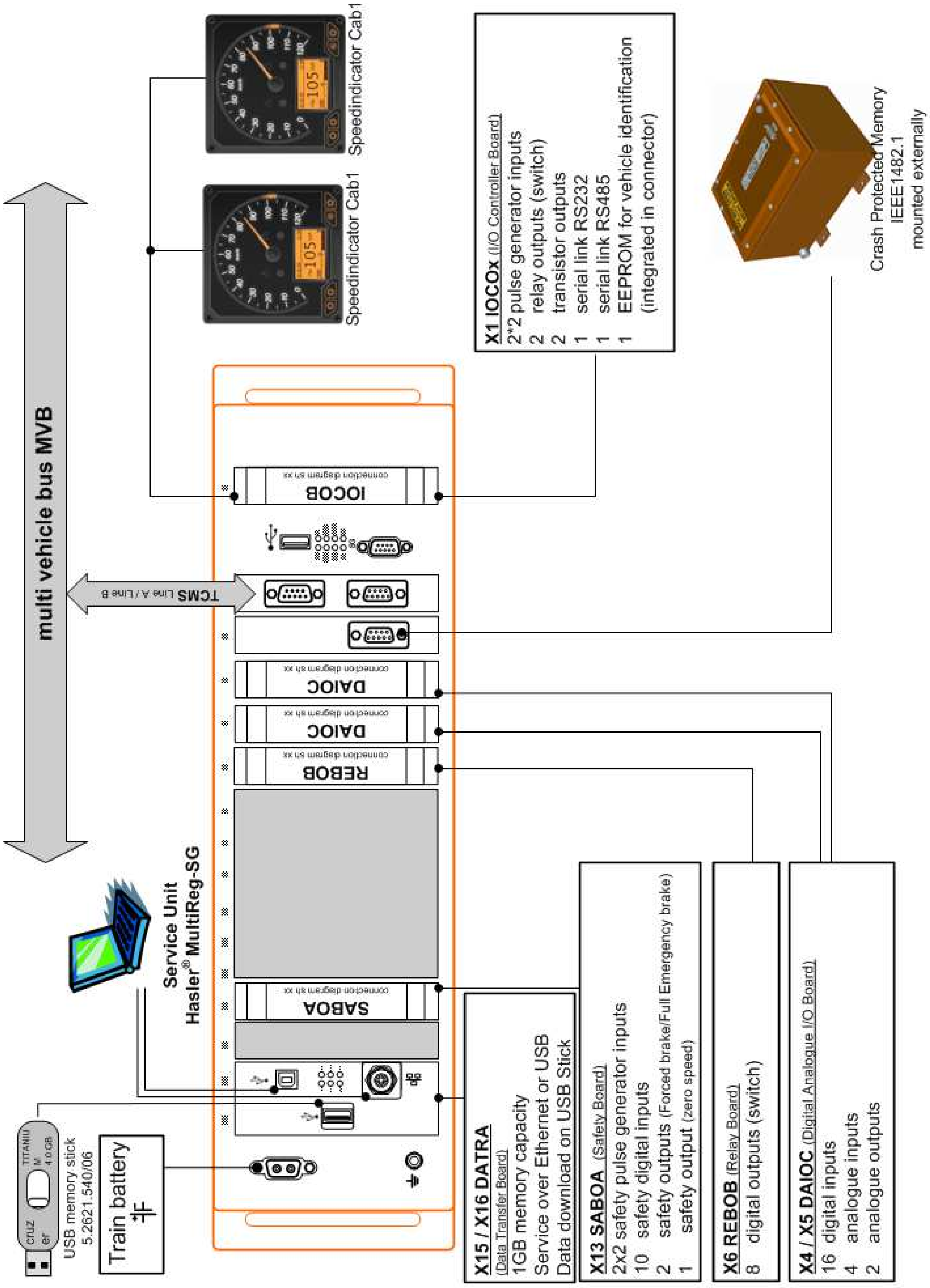
The TELOC® family of event recorders are designed and engineered for a broad range of applications in locomotives, DMU's, EMU's (incl. the fastest high speed trains), Metros, Trams etc. The equipment can be adapted to different configuration needs, for example:

- Combinations of discrete in- and output hardware and train bus signal recording.
- Event Recorders with up to 144 I/O events recorded with special functions: Vigilance System, Speed Indication Monitoring, Rollback Monitoring, Direction, Wheel Slide & Skating Detection, Automatic Time Correction, etc.
- Crash Protected Memory Module (64MB); IP67; according to standard IEEE1482.1
- Advance Memory and Communication functions for recording of great amount of data and fast data download possibilities.

The TELOC® is part of a high-tech equipment generation that satisfies the most demanding requirement of driving safety and control. Due to the open architecture of the system, new functions can be integrated at the hardware level.

5.2 *System Overview*

To meet the requirements specification for the Cincinnati project HaslerRail proposes the following TELOC®1500 concept:



5.2.1 Bill of Materials

The system comprises on board (per train):

- 1 x TELOC®1500 equipment including each:
  - 1 x 2 poles D-sub mating-half connector for power supply board
  - 5 x 48 poles mating-half F-connectors for IOCOB, DAIOC and REBOB board
  - 2 x 9 poles D-sub mating-half connectors for MVB board
- 2 x Speedo equipment including each:
  - 1 x 15 poles connector for Speed display
  - 1 x 25 poles connector for Speed display

None on-board equipments proposed:

- Hasler®MultiRec-SG Service Software Tool
- Service connection cables for Laptop to TELOC® communication
- 1 x TELOC®EVA Evaluation Software Tool

5.2.2 Short System Description

The TELOC®1500 proposed for this project is housed within a robust protective IP40 enclosure The electronics inside the TELOC® unit are connected together through a VME bus. A “Plug and Play” system is used, which means that software detects the type of board fitted within the TELOC®, automatically configuring the system and making it extremely flexible and easy to maintain. There is also an internal PC/104 interface on the processor board to connect the MVB train bus.

The TELOC®1500 itself is maintenance free. The maintenance of the complete system (clock adjusting, vehicle number, wheel diameter, etc.) if necessary is realised by the service unit software MultiRec-SG.

The TELOC®1500 system realises the measurement, the recording and the indication of the speed in each driver cab. The speed information is acquired from 2 speed sensors. The axle pulse generators with 2 speed sensors allow to detect the train direction and give a high availability of the system. The train speed is then sent to the Train Control Network via MVB.

Remark: If no Hasler Speed sensors are used, then the type of speed sensors used has to be checked by HaslerRail.

In order to safe data in case of incident, fire, accident or other hard circumstances during train operation, recorded data is saved twice, once onto the Processor board,in the DATRA memory, and onto the Crash Protected Memory.

Further the TELOC®1500 realizes the driver vigilance functionality, roll back protection and zero speed indication through the Safety Board SABOA . A safety acquisition of the speed is realised by 2 speed sensors fixed on the wheels of 2 separated axles. The Emergency Brake signal is delivered to the brake system through 2 safety digital outputs.

On the DATRA board, the memory capacity of 850MB is available. This data can be downloaded by a USB 2.0 and a fast Ethernet interface.

The system comprises on board (per train):

- 1 x Power Supply board type POSUE from 24 to 110 Vdc
  - 1 x 2 poles D-sub mating-half connector for power supply board
- 1 x Main Processor Unit board type COREB of 64 MB (data flash memory) with
  - Power back up from Accumulator
  - Service line RS232 for Notebook connection (service & maintenance)
  - USB interface for fast data download
  - LED's status indicator
- 1 x Input / Output Communication Interface board type IOCOB with
  - 4 frequency or PWM inputs
  - 1 serial line RS485 to the Crash Protected Memory mounted inside
  - 2 transistor pulse outputs
  - 2 changeover relay outputs
  - 1 x 48 poles mating-half F-connectors whit EEPROM for IOCOB board
- 1 x Crash Protected Memory (CPM) of 64 MB, mounted outside the TELOC® with
  - 1 RS485 interface
- 1 x Cable to connect the TELOC® and the Crash Protected Memory (1.5m)
- 1 x MVB board for TCN communication with
  - 2 EMD interfaces for redundancy
  - Class 1
  - 2 x 9 poles D-sub mating-half connectors for MVB board
- 2 x Digital & Analogue In- / Output board type DAIOC with interfaces to
  - 4 analogue inputs
  - 16 digital inputs
  - 2 analogue outputs
  - 2 x 48 poles mating-half F-connectors for DAIOC boards
- 1 x Relays board type REBOB with interfaces to
  - 8 changeover relay outputs
  - 1 x 48 poles mating-half F-connectors for REBOB board
- 1 x Safety board SABOA with interfaces board to
  - 4 frequency or PWM inputs
  - 10 digital inputs (Predefined for Safety functions)
  - 3 digital outputs (Predefined for Safety functions)
  - 1 x 48 poles mating-half F-connectors for SABOA board
  - 1 x 48 poles mating-half F-connectors SABOA for configuration
- 1 x Communication board type DATRA
  - 10/100 Ethernet
  - Memory full alarm
  - USB 2.0 Interface
  - 800MB flash memory
- 2 x SPEEDO
  - Led Ring to define the maximal speed
  - 4 programmable lamp indicator
  - 4 programmable button
  - SIL2 Certified

5.3 *Detailed description TELOC®*

5.3.1 Main Data TELOC®1500

The following are the main electric and mechanical characteristics of the TELOC®1500:

General specification	*TELOC®1500*
Power supply	24 – 100 V_{DC}
Current consumption	43 W
Protection	IP40
Room temperature	-25˚C up to +70˚C (EN 50155, class T3)
Relative humidity	95% for 30 days / year
Standards	EN 50155, EN 50121-3-2
Mechanical tests	Shock and vibrations according to EN 50155
EMC tests	EN 50121-3-2
Temperature tests	EN 50155, class T3
Earthing	M4 screw on the frontal plate of the TELOC®
Weight	approx. 7 kg

Internal real time clock	
Data	Day, month, year, hour, minute and second Self correction for leap years. Self correction for GMT – BST.
Accuracy	< 1 second per day for the whole temperature range
Backup power supply	Lithium accumulator 3 V (nominal capacity 20 mAh) Rechargeable, maintenance-free

Frequency inputs	
Coupling	Non-isolated (isolated coupling possible with reduced characteristics)
Isolation voltage	Not applicable (in case of isolation : 1kVeff / 50Hz / 1 minute)
Voltage signal (frequency)	LOW state < 3V HIGH state > 7V direction detection: yes, if 90° shift between sensors
Current signal (frequency)	LOW state < 9 mA HIGH state > 21 mA
Output Voltage supply	**12 V (for pulse generator or other)**

Pulse outputs (transistor outputs)	
Coupling	Opto-coupler
Isolation voltage	1kVeff / 50Hz / 1 minute
Switching voltage	Max. 140V
Switching current	Max. 120mA
Frequency	Max. 500Hz (20V, 200Ω, 25°C)

Analogue inputs	
Coupling	Opto-coupler
Isolation voltage	1kVeff / 50Hz / 1 minute
Measuring voltage range	Up to +/-10VDC or
Measuring current range	0 - 20 / 4 - 20 mA
Sampling frequency	50Hz

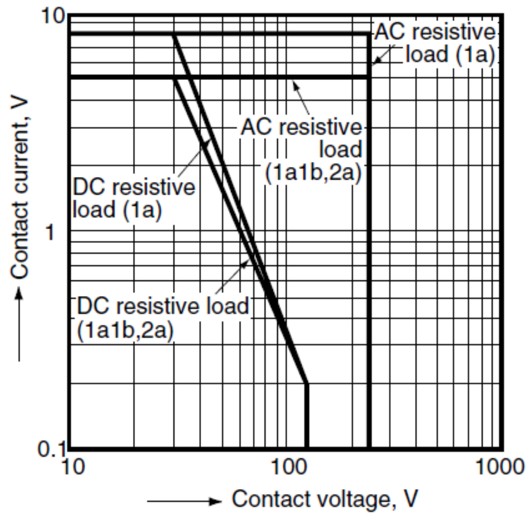
Sweep / input interval	5ms

Analogue outputs	
Coupling	Opto-coupler
Isolation voltage	1kVeff / 50Hz / 1 minute
Voltage range	0 - 10 V single-pole or
Current range	0 – 20 / 4 – 20 mA single pole
Load impedance	400Ω for current output high if possible for the voltage output (>1kΩ)
Accuracy	<1%

Digital inputs	
Coupling	Opto-coupler
Isolation voltage	1kVeff / 50Hz / 1 minute
Voltage range	Up to ± 150VDC
Threshold values	Logic 0 <10V. Logic 1 >14V
Input current	8mA ± 20%
Sampling frequency	50Hz
Sweep / input interval	5ms

Digital outputs	
Interruption power	Max. 100W (only resistive load)
Switching voltage	Max. ±140VDC (only resistive load)
Switching current	Max. ±1.3ADC @ 72VDC Min. 10mA (wetting current)
Inductive load	To be connected with a free-wheeling diode

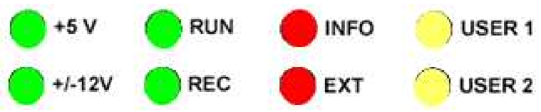
1. Max. switching capacity



Communication interfaces	
MVB	2 x EMD interfaces for redundancy

5.3.2 LED Display

On the front plate of the DRU is a LED panel by which the user is able to check on the current operational status.



LED	Condition	Meaning
green +5V	Lights	+5Volt power supply is within the correct range
green +/-12V	Lights	+/-12Volt power supply is within the correct range
green RUN	Blinking	Indicates correct operation of the SW
	Dark	Indicates a SW error
green REC	Lights	Data recording is working correctly
	Blinking	Simple alarm, Warning; makes the user aware of a non-serious fault in the system. Journey data continues to be recorded; the vehicle can remain in service.
	Dark	Fatal alarm; the recording of the journey data is interrupted. DRU has to be replaced, i.e. vehicle must in most cases be taken out of service
red INFO	Lights [LED REC is blinking or dark]	Indicates a fault in the unit itself (e.g. communication error). The system will switch to a standby mode where only communication with the MultiRec-SG SW is possible. (Read error message, fix problem and erase the error message)
red EXT	Lights [LED REC is blinking or dark]	Indicates a fault on a peripheral unit
amber USER 1	Blinking	When downloading data via USB, these LEDs are used to indicate the status of the USB data transfer
	Dark	No special function, this is the normal state
amber USER 2	Blinking	MVB Communication active. When downloading data via USB, these LEDs are used to indicate the status of the USB data transfer
	Dark	MVB Communication inactive.

5.3.3 Teloc Hardware

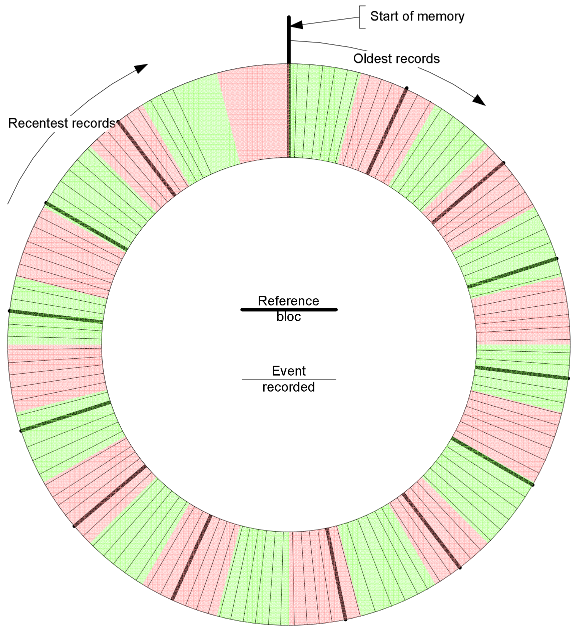
The specific electronic units proposed for this project are described in this section.

Power supply..POSUE type

Fed from the battery voltage, the unit provides the necessary regulated power for the TELOC®. It is designed to comply with the control voltage variation and interruption specification of EN50155 and the EMC requirements of EN50121-3-2. The power supply is fully protected against reversal of input voltage and output short circuit. The unit also monitors the input voltage so that if this falls under a certain level, a signal is produced, which is used by the processor to ensure that data is backed up correctly. See more details of board on data sheet in attachment.

Main processor and memory board..COREB type

This board contains the processor, memory for the operating program and the recording of journey data, a real time clock and serial interfaces.



Non-volatile, flash memory with a capacity of 64MB is used for the data recording function.
The memory on COREB, as well as the memory on the CPM is a circular buffer, i.e. that the architecture is FIFO (First in – First out), see picture beside.
The memory is subdivided into many flash memory sectors of 128Kbytes, which get filled with the recorded data. Once the last sector gets saved data into it, i.e. there is less than 126Kbytes free in the last sector, then the first sector is erased.

The real-time clock is powered from an accumulator, which guarantee:

The USB port is used to download stored journey data into an USB stick. The RS 232 serial link port (Service IF) is designed for use with the service unit software MultiRec-SG for service and maintenance of the TELOC®.

An 8 LED's status indicator is located on the front of the equipment in order to allow a fast and simple check of the functioning of the system.

The board is fitted with a PC/104 interface for the internal connection of the MVB board.

Input / Output Communication Interface board……………………………………………..…..IOCOB type

The board provides following functions:

- 4 frequency or pulse (PWM) inputs
- 2 transistor pulse outputs
- 2 changeover relays with volt free contacts (digital outputs)
- 2 serial lines RS485 for speed indication
- 1 serial port RS485 port to connect the Crash Protected Memory
- 1 serial port RS485 port to connect an LCD display or for other application
- 1 interface for the data stored on the vehicle identification EEPROM

See more details of COREB and IOCOB boards on data sheet.

Digital & Analogue In- / Output board……………………………………………………………DAIOC type

All digital and analogue inputs and analogue outputs are galvanically isolated from the data recorder metalwork and the electronics using opto-couplers. Digital inputs are arranged in groups of 4 that share a return; an arrangement that ensures that the risk of accidental cross feed or grounding of signals is minimised. See more details of board on data sheet.

The DAIOC digi board has only 16 digital inputs.

MVB board: Type MVB Class 1………………………………………………………………………………MVB

The MVB board connected to the redundant TCN allows to receive data from others sources (as for example the date and time to synchronize the internal real time clock RTC) and to send data to the Train Computer (as for example status and values of parameters). The MVB board provides 2 interfaces to the TCN. In this way only one board is necessary. If necessary, the redundancy is internally managed by the MVB board. The MVB board is fully compatible with the TCN Standard according to IEC61375 with the specified conditions: Message Data Class1 and Electrical Middle Distance (EMD).

The data transmitted through the MVB are managed by the COREB board via PC/104 interface.

Relay board...REBOB type

The REBOB board is equipped with 8 relays each with a changeover contact. These programmable digital outputs can be controlled based on speed, time or distance. As with the IOCOB board, this means that control pulses can be switched to electromagnetic kilometre counters, flange lubrication or external systems or speed-dependent functions. See more details of board on data sheet.

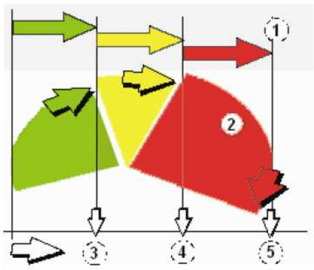
Ethernet communication board ………………………………………………………………DATRA type

The aim of this board is to provide external ports to download data in a fast way through USB and Ethernet.
The USB and Ethernet port are used for service and maintenance of the TELOC®.
The Ethernet connection allows to transfer data via other paths, e.g. via a WiFi hub for future applications.
LED's on the front plate show the DATRA status.

Safety board …………………………………………………………………………………………SABOA type

The automatic vigilance device serves as an automatic train control device on track as well as a driver monitoring device during operation. It constantly monitors the driver's ability to react by having to reset a cycle triggered by configurable criteria. If the cycle is not reset an automatic brake application is triggered after one or more alarm levels have been run through.
The automatic vigilance cycle type is either configurable to distance or time or as a mixed cycle type. The following diagram shows such a cycle.

1 – distance-dependant cycles
2 – time-dependant cycles
3 – Lamp
4 – Horn
5 – Brake application
Automatic vigilance device cycle diagram



Roll Back Protection

The Rollback protection is integrated into SABOA.
The control monitors the driving direction of the vehicle and compares the detected direction to the target driving direction selected with the selector switch.
If the detected driving direction does not match the target driving direction is detected, then after a rolling distance of 0.2m, the Full Emergency Brake is triggered.

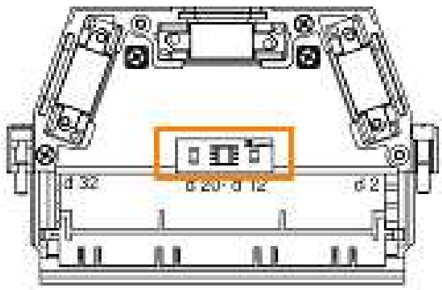
Vehicle identification device

Vehicle identification information is stored on an EEPROM located in the connector of the IOCOB board.

The connector remains on the cabling of the vehicle and some important information of the TELOC® will remain stored in the connector. After exchange of a TELOC® the information will be automatically read from the EEPROM.

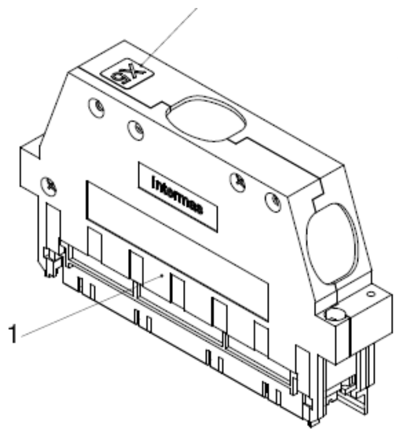
Following vehicle related data are stored:

- Wheel diameters (up to 4 values)
- Vehicle number
- Distance counter

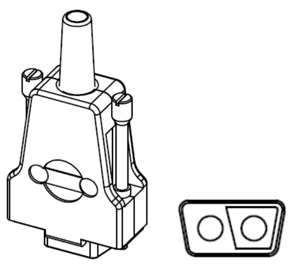


Connectors

Connector DIN 41612 F



connector DSUB for power



5.4 *Detailed description TELOC®*

HaslerRail has the Crash Protected Memory (CPM) model in its range as additional options.
These are separate data storage units which can be connected to a TELOC®. A copy of the external TELOC® memory (journey and vehicle information) is stored in these data storage units, which have been specially designed to withstand fire and impact. The MultiRec-SG software is used to read the journey data.

The CPM is a self contained rugged unit that complies with the requirements of the American standard IEEE1482.1.

The CPM allows the recording of all data recorded in the internal memory of the Event and the JRU recorder.
Interface: RS485, full duplex realised through D-sub 9-poles connectors.

5.4.1 Main Data Crash Protected Memory according to American standard

American Standard	IEEE 1482.1
Memory	Up to 64MB
Protection / sealing	IP67
Fire protection	650°C for 30 minutes, followed by 300°C for 60 minutes, followed by 100°C for 5 hours
Impact / shock	± 55g peak for 100ms duration, ½ sine crash pulse, no less than 28m/s velocity area under curve, separately in the direction of the three principal axes
Static crush	110kN for 5 minutes.
Fluid immersion	Immersion in grade 1 and 2 diesel fuel, regular and salt water and lubricating oil for 48 hours; Immersion in fire-extinguishing fluids for 10 minutes, followed by 48 hours in a dry location.
Magnetic field	64kA at 1m

Hasler® CPM
IEEE Std 1482.1
Part 4.5

5.5 *Detailed description SPEEDO®*

The indication must be sufficiently accurate to enable the driver to keep to his timetable and maintain optimum control over the vehicle in critical situations.
The indicator unit must be extremely reliable and must warn the driver of the possibility of false readings in the event of a fault condition.
Combining several readings (e.g. Vactual, Vnominal) in one indicator makes it easy to compare them and saves space on the driver's instrument panel.
The indicator is controlled by a step-motor and an electronic control system which converts the input signal (nominal) into the pulses which drive the step-motor.
The correct position of the pointer is checked internally by a feedback-encoder system. The entry signal is compared to the feedback signal.

5.5.1 Main Data Speedo

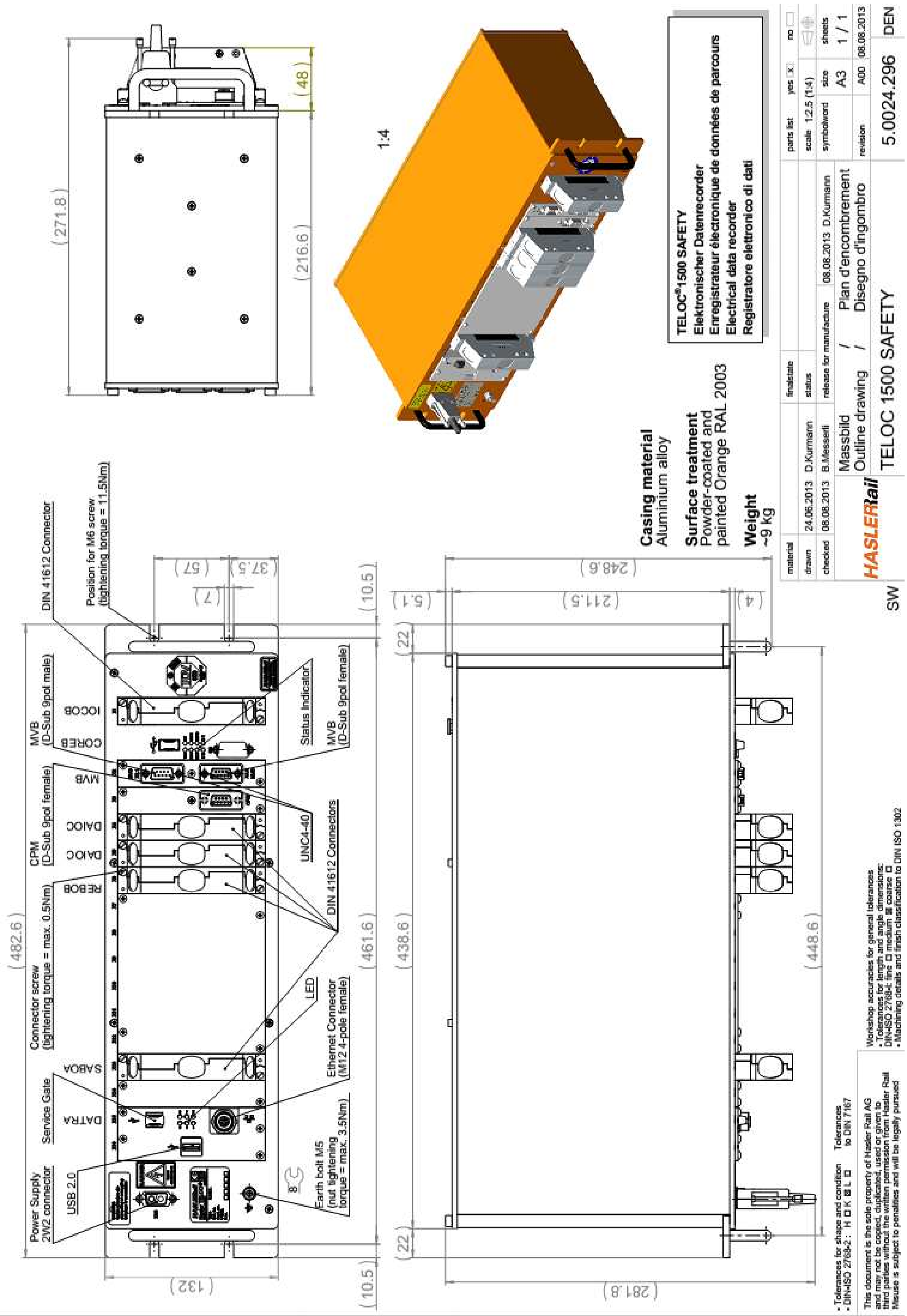
General specification	
Power supply	24 – 100 V_{DC}
Current consumption	10 W
Protection	Front IP 54, Back IP20
Standards	EN 50155, EN 50121-3-2; EN 61373
Mechanical tests	Shock and vibrations according to EN 61373 Category 1, ClassB, body mounted
Accuracy	Vactual ± 0.5% of maximum value (pointer) Vnominal ± 1% of maximum value (LED ring)
Weight	1.2 kg
Interfaces	Service Ethernet / USB, RS485 (on request), CAN(on request)

Inputs	
AI-Vactual	0-20mA or 4-20mA or 0-10V
AI-Vnominal	0-20mA or 4-20mA or 0-10V
DI-Lamp A	Uon > 12V, Uoff < 5V
DI-Lamp B,C,D and Flag	External contact

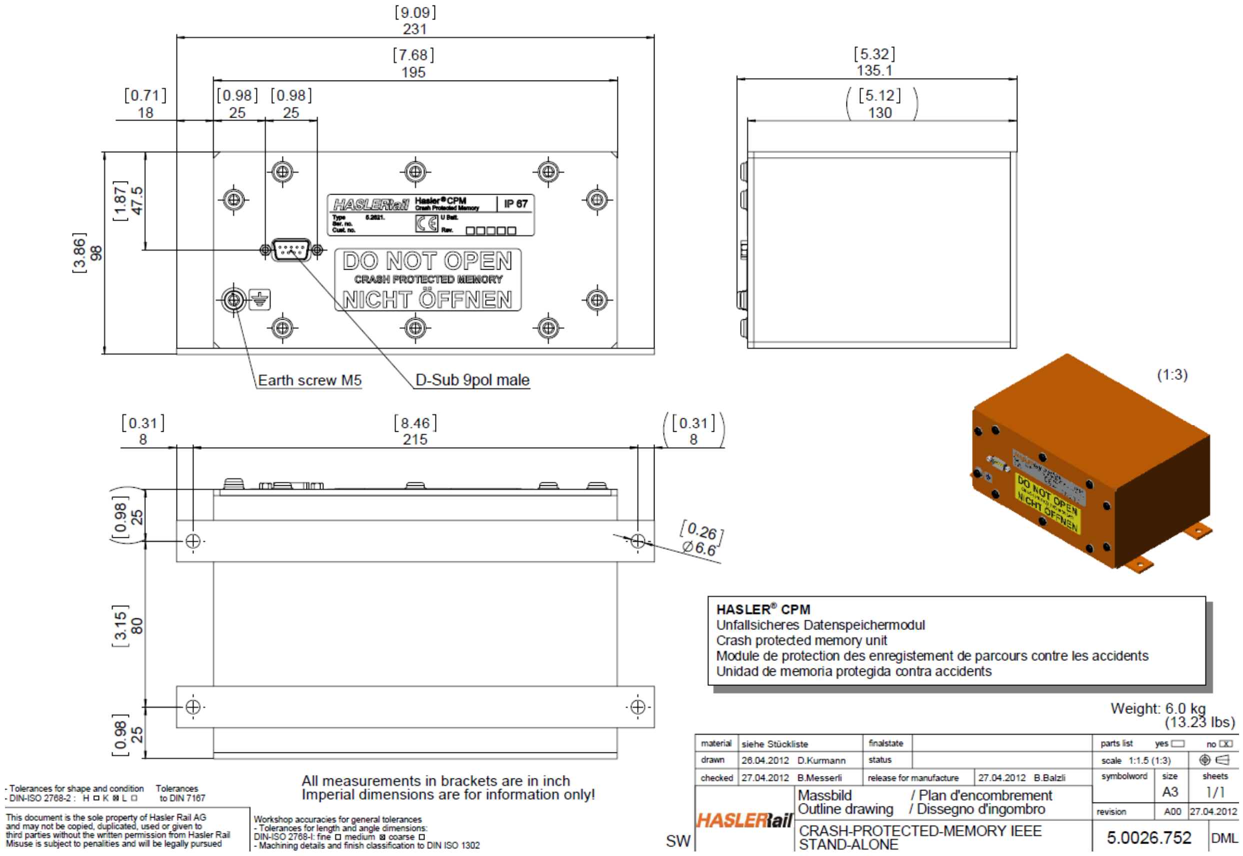
Outputs	
AO-Pointer position feedback	0-20mA or 4-20mA or 0-10V
DO-Vmax alarm	Relay contact

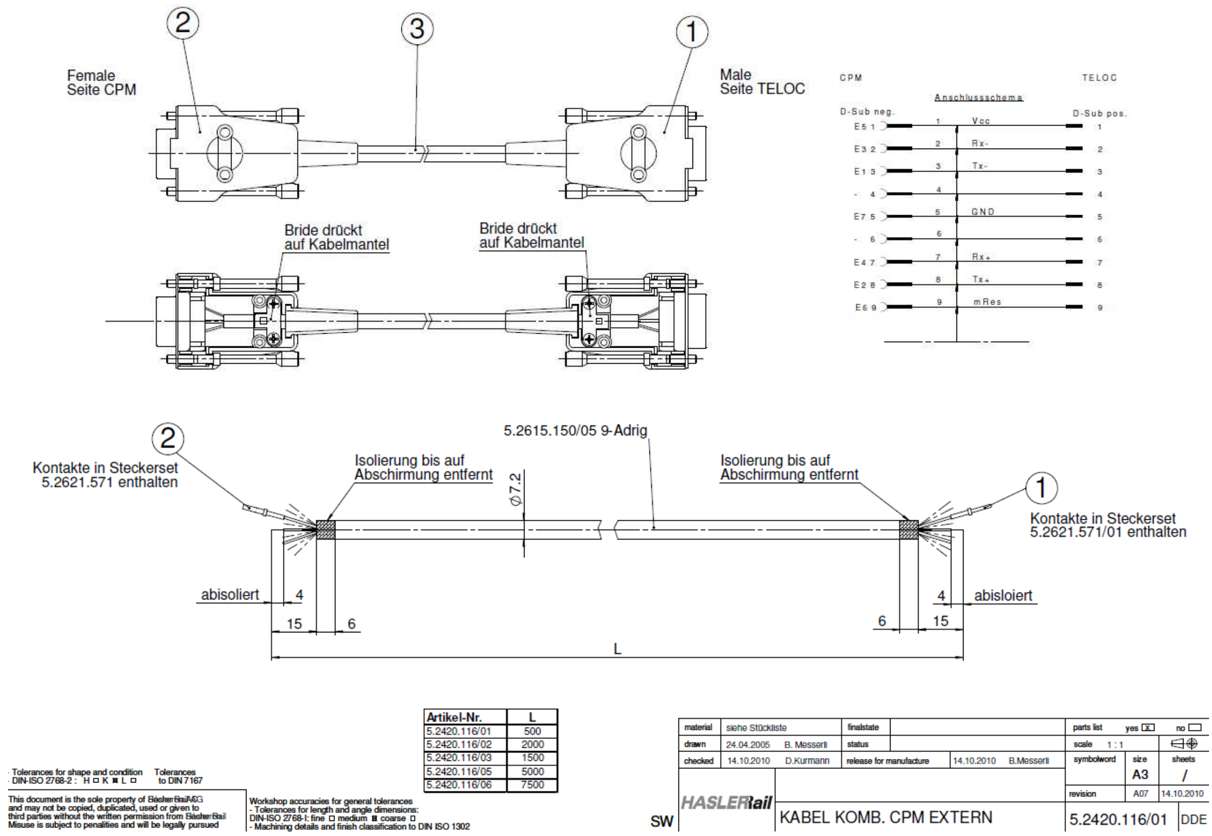
5.6 *Outline drawings*®

5.6.1 TELOC

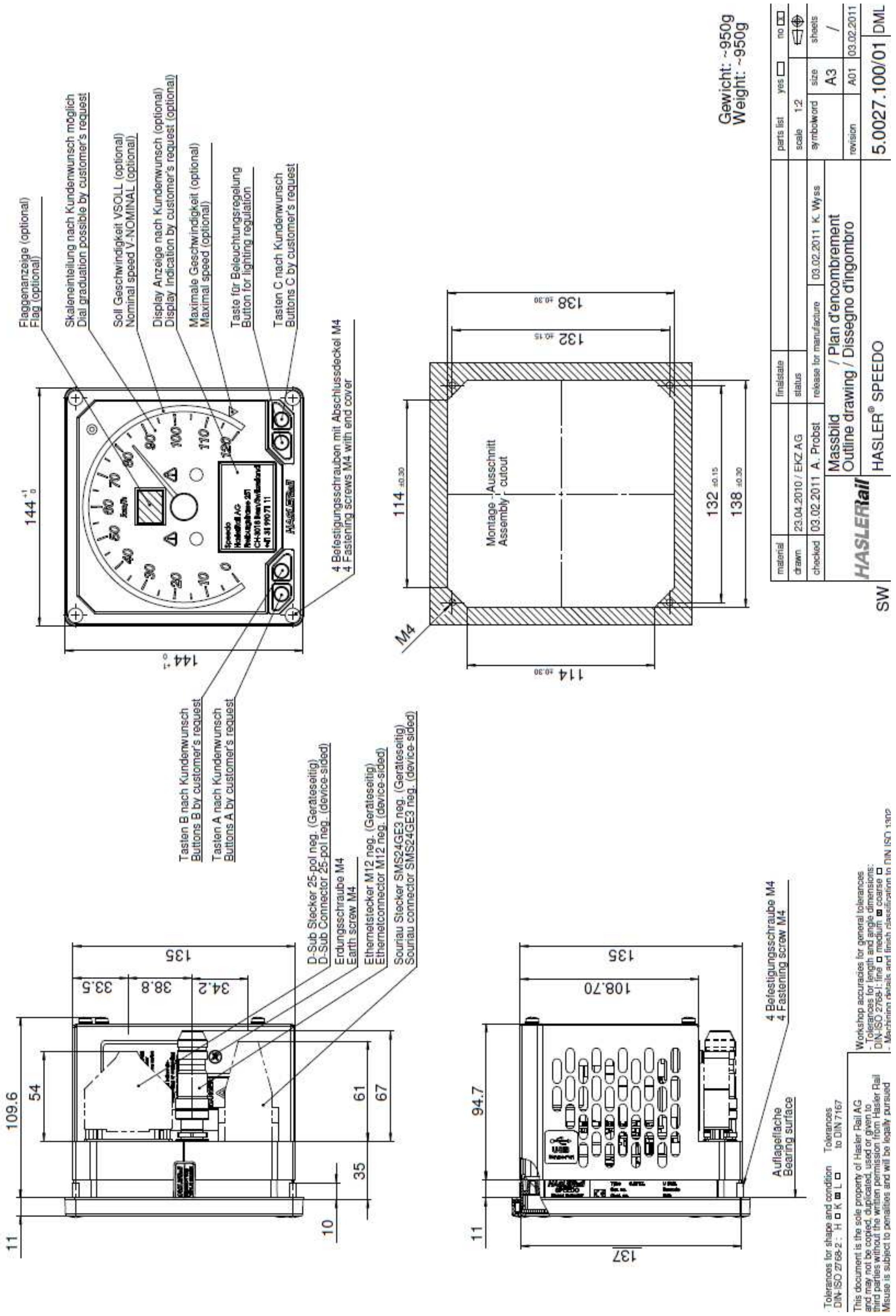


5.6.2 CPM


[9.09]
231
[7.68]
195
[0.71]
18
[0.98] [0.98]
25 25
[5.32]
135.1
[5.12]
130
[1.87]
47.5
[3.86]
98
DO NOT OPEN
CRASH PROTECTED MEMORY
NICHT ÖFFNEN
Earth screw M5
D-Sub 9pol male
(1:3)
[0.31]
8
[8.46]
215
[0.31]
8
[0.98]
25
[0.26]
Ø6.6
[3.15]
80
[0.98]
25
HASLER® CPM
Unfallsicheres Datenspeichermodul
Crash protected memory unit
Module de protection des enregistement de parcours contre les accidents
Unidad de memoria protegida contra accidents
Weight: 6.0 kg
(13.23 lbs)
All measurements in brackets are in inch
Imperial dimensions are for information only!
material siehe Stückliste
drawn 26.04.2012 D.Kurmann
checked 27.04.2012 B.Messerli
release for manufacture 27.04.2012 B.Balzli
scale 1:1.5 (1:3)
size A3
sheets 1/1
revision A00 27.04.2012
Massbild / Plan d'encombrement
Outline drawing / Dissegno d'ingombro
CRASH-PROTECTED-MEMORY IEEE
STAND-ALONE
5.0026.752
DML
SW


Female
Seite CPM
Male
Seite TELOC
Bride drückt
auf Kabelmantel
Bride drückt
auf Kabelmantel
CPM
TELOC
Anschlussschema
D-Sub neg.
D-Sub pos.
Vcc
Rx-
Tx-
GND
Rx+
Tx+
mRes
5.2615.150/05 9-Adrig
Kontakte in Steckerset
5.2621.571 enthalten
Isolierung bis auf
Abschirmung entfernt
Ø7.2
Isolierung bis auf
Abschirmung entfernt
Kontakte in Steckerset
5.2621.571/01 enthalten
abisoliert
abisloiert
L
Artikel-Nr. L
5.2420.116/01 500
5.2420.116/02 2000
5.2420.116/03 1500
5.2420.116/05 5000
5.2420.116/06 7500
material siehe Stückliste
drawn 24.04.2005 B. Messerli
checked 14.10.2010 D.Kurmann
release for manufacture 14.10.2010 B.Messerli
scale 1:1
size A3
revision A07 14.10.2010
KABEL KOMB. CPM EXTERN
5.2420.116/01
DDE
SW

5.6.3 SPEEDO



Author	Andy Gonzalez	25.03.15	**TELOC 1500 Cincinnati**		
Revised	Remo Spinosi	25.03.15			
Authorized	Andy Gonzalez	25.03.15	Nos reservamos todos los derechos de este documento y de la información que contiene. Se prohíbe terminantemente la reproducción, el uso y la divulgación a terceros sin autorización escrita. © HaslerRail AG	**5.2421.122/01V01**	20/27
Version	**F**				

5.7 *Functional Description*

5.7.1 Data recording

The TELOC®1500 equipment is designed to record the speed and to collect analogue signals such as the motor current, overhead wire voltage, brake pressure, as well as digital signals such as whistle, moving direction, brake and signals. As a function of the captured signals, various control functions such as speed monitoring, deadman can be executed.

The TELOC®1500 equipment can receive the data from discrete (hard-wired) signals and / or from the train communication network system. The data can be recorded in different types of memory.

Usually, the following memory types are used by HaslerRail:

Residual distance memory (STM): also called **S**hort **T**erm **M**emory. In this memory, the signals are recorded with a high resolution, since the exact and detailed recording of speed as well as digital and analogue signals of the last covered distance are used for accident data analysis.

Long term memory (LTM): This memory has a large capacity and records the speed as well as digital and analogue signals over a longer period, though less detailed as the residual distance memory and thus serves as a vehicle journey log.

Event memory (EVM): This memory, disposes mostly over a small capacity. Furthermore, the event memory can also be used like a residual distance memory or a LTM and may be configured like an STM or LTM.

Error messages and information (ERR, error memory): If the microprocessor detects a discrepancy in the test routine, this is signalled with a LED in the status block and simultaneously generates an entry in the error memory. Furthermore, much different information is stored in this memory, e.g. powering up or shutting down the TELOC®.

5.7.2 Estimated recording time

Depending on how precisely the resolution (DBR) of the analogue signals is chosen and depending on how often analogue or digital signals change (speed variations, door open/close etc.) the recording time varies.

Assuming the signals vary in such a manner that the train speed is recorded every 0.5 seconds, other analogue signals (e.g. brake pressure, traction signal) every 10 seconds and digital signals every 80 (e.g. direction, doors etc.) seconds we have calculated the following recording time for 128 digitals and 16 analogues input signals.

This estimation will be calculated considering that the Tram is only driving 16 hours per day and 8 hours stand still:

	Memory size [MB]		Memory division [%]	[MB]
Mainboard / CPM	64	Memory 1 *Short Term Memory*	20	12.8
		Memory 2 *Long Term Memory*	80	51.2

		Memory 1	Memory 2
Data retention	[hours]	6.1	140.7
	[days]	0.4	8.8

5.7.3 File name

As already mentioned, DATRA board builds the file name and format for an easy use of the fleet management with a great amount of data.
The filename will be in form of:[free definition]_Rawxxxx.tel ; where Rawxxxx is the file numbering; the number xxxx will not have a constant length, it starts from 0 and is theoretically unlimited. The extension is always ".tel" for these files.

The free definition can be configured into the TELOC® as follow (to be mutually agreed):

- Serial number of TELOC®

- Customer ID

- Vehicle ID

- Vehicle type

- End date, End time

- Start date, Start time

The user can also introduce text in the free definition, except the string "Raw".

Further package of data can be limited to a defined size or time (for example each package is a 24 hours time recording of data).

5.7.4 File format

Basically, the idea of the file format is to generate only one file which will contain all information necessary for the evaluation. The file will contain all the selected memory types and at least the configuration.

The error and diagnostic are required, but must not absolutely be present for the evaluation.

It is possible to extract a part (a memory type) from the file as for example STM or LTM data.

The idea is to use the standard .tar archive format to store the data into this unique file. The different raw data files from the different memory types will be concatenated into one unique file together with the configuration, the error and diagnostic files. Additionally, a header file describing the contents of the file will be added into this file; this header file will be written in XML.

Header file (XML)
Configuration file
Diagnostic file
Error file
STM data file (residual distance data)
LTM data file (long term)
Etc.

The header will be an overview of the contents, for example the range of the raw data available in the file, the source of the data, vehicle information, version…

5.7.5 Signal treatment: Record, Display and Control

The recorded signals are processed according to the configuration programmed into the device whereas the following alternatives are possible:

- Recording in the activated TELOC®1500 memories, both in the internal memory and in the shock and fireproof memory
- Emission of analogue signals e.g. to control the speed indicator
- Emission of digital, speed-dependent switching signals to control peripheral
- devices or to link input signals
- Vehicle bus signals (e.g. RS485, MVB, CANopen, Profibus, etc.)

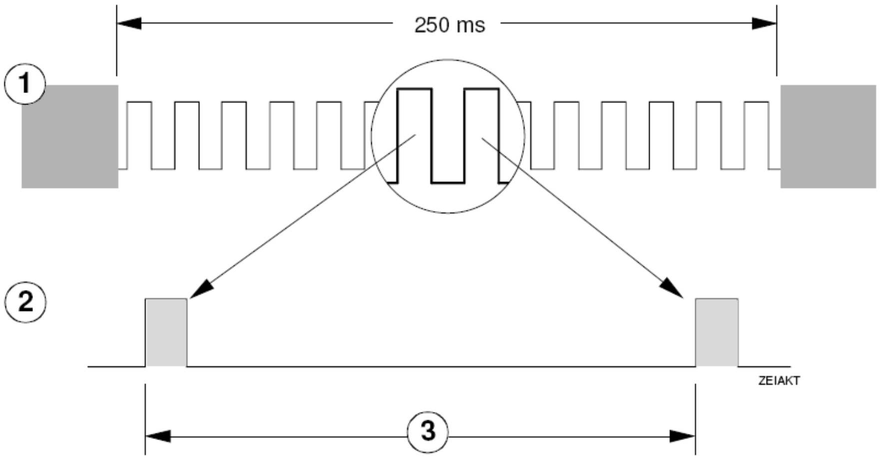
5.7.6 Speed measuring procedure

There are two speed probes hardwired to the TELOC. Each speed probe generates a pulses signal with a frequency which is proportional to the speed of the train. Each pulse input is configured as analogue input, allowing the interpretation of the measured frequency. The TELOC 1500 calculates the speed of the train on the basis of 2 criteria that we will call "Low speed" and "High speed".

If, with rising speed, the number of pulses rises above 400 pulses per second (pps), the system switches to the *"High Speed"* criterion; if, vice versa, the number of pulses drops below 320 pps, the system switches to the *"Low Speed"* mode.

In *"Low speed"* mode, the speed is computed from the time between two pulses, where as the first pulse launches a counter being stopped by the second pulse. The actual speed is then differentiated from the counter value. If no further pulse is registered until the counter reaches its maximum value (FFFF), this is defined as vehicle standstill or zero speed.

In *"High speed"* criterion, the speed is computed from the number of pulses registered in a 250 ms time slot.



Measuring cycles high speed – low speed

1 "*High speed*" criterion 2 "*Low speed*" criterion 3 Time between two pulses

With 2 speed sensors, by default the higher frequency detected is used to compute speed and distance. The TELOC deduces the speed by means of the following formula:

$$Vn = \frac{Mn}{T} \times \frac{\pi D}{N} \times 3{,}6 Km/h$$	*Vn:*	Speed calculate (km/h)
	T:	Interval of measure (secondes)
	Mn:	Number of pulses during the interval of measure T.
	πD: .	Perimeter of wheel in meters (value comprise between Dmax= and Dmin=).
	N:	Number of pulses during one Wheel revolution (140)
	3,6:	Conversionfactor m/s to Km/h

The TELOC deduces also the distance covered by means of the following formula:

$$Sn = VnxT = Mn \times \frac{\pi D}{N} meters$$

The distance covered is incremented by the TELOC every T=20ms

5.7.7 Criteria for data recording

The recorders of events TELOC make recording by event, this means that the signals are registered according to the established criteria as indicated next:

- **Digital Inputs wired to TELOC** must respect the specified *low* and *high-levels (<10 VDC and. >14 VDC respectively)*. Each one of the input is recording in the memory when a change of state in the signal is detected. The TELOC samples the digital inputs each 20ms and a change of state is detected if the same value in the signal persist during at least 5 consecutive cycles (software filter). Therefore changes in the signal that persist less than 100 ms are not recorded in the TELOC memory.

  For **digital input received via MVB** the TELOC records the signal if the state received has changed with respect to the state previously received.

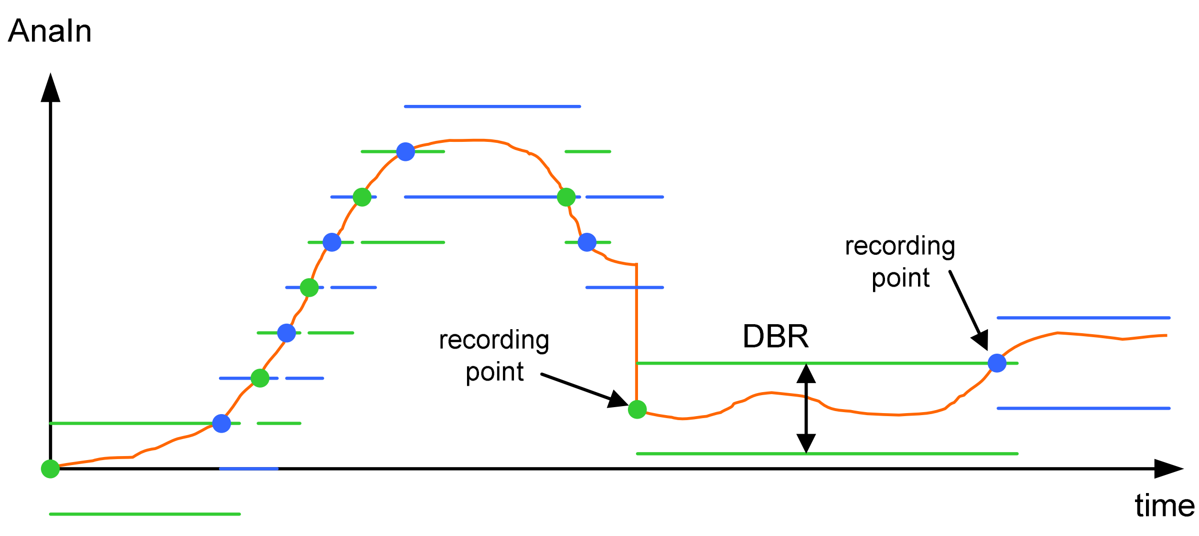
  Each input is recording with a user defined name and are time, date and distance stamped.

- **Analog signals wired to TELOC** must respect the specified voltage or current levels. They are though not registered as signal values persisting at the input but are transferred in the physical units corresponding to the signal's origin (pressure in [bar], current in [A]). The conversion is only possible in a linear way, the corresponding parameters are allocated to each input by the configuration.

  The recording resolution of speed and analogue signals can be defined individually. For each signal, a trigger criterion, a "*Deviation Before Recording*" *(DBR)* can be defined in % of the maximum value or in a fixed signal value (e.g. pressure changes of < 0.1 bar are not recorded).
  For **pulse signals** a DBR can be defined for the minimum- as well as for the maximum value. The DBR changes proportionally to the pulse signal's modification (and thus the speed) between the two defined boundary values.

  Analog signals wired to TELOC and received via MVB are recording if the actual value differs from the previous value for more than the DBR range. Simultaneously, the distance and/or time can be registered.

  If the signals remain unchanged for a longer time or distance and therefore no recording is triggered by signal change (event), reference recordings of all signals take place in regular, configurable time- or distance intervals. These reference recordings are individually configurable for each memory type.



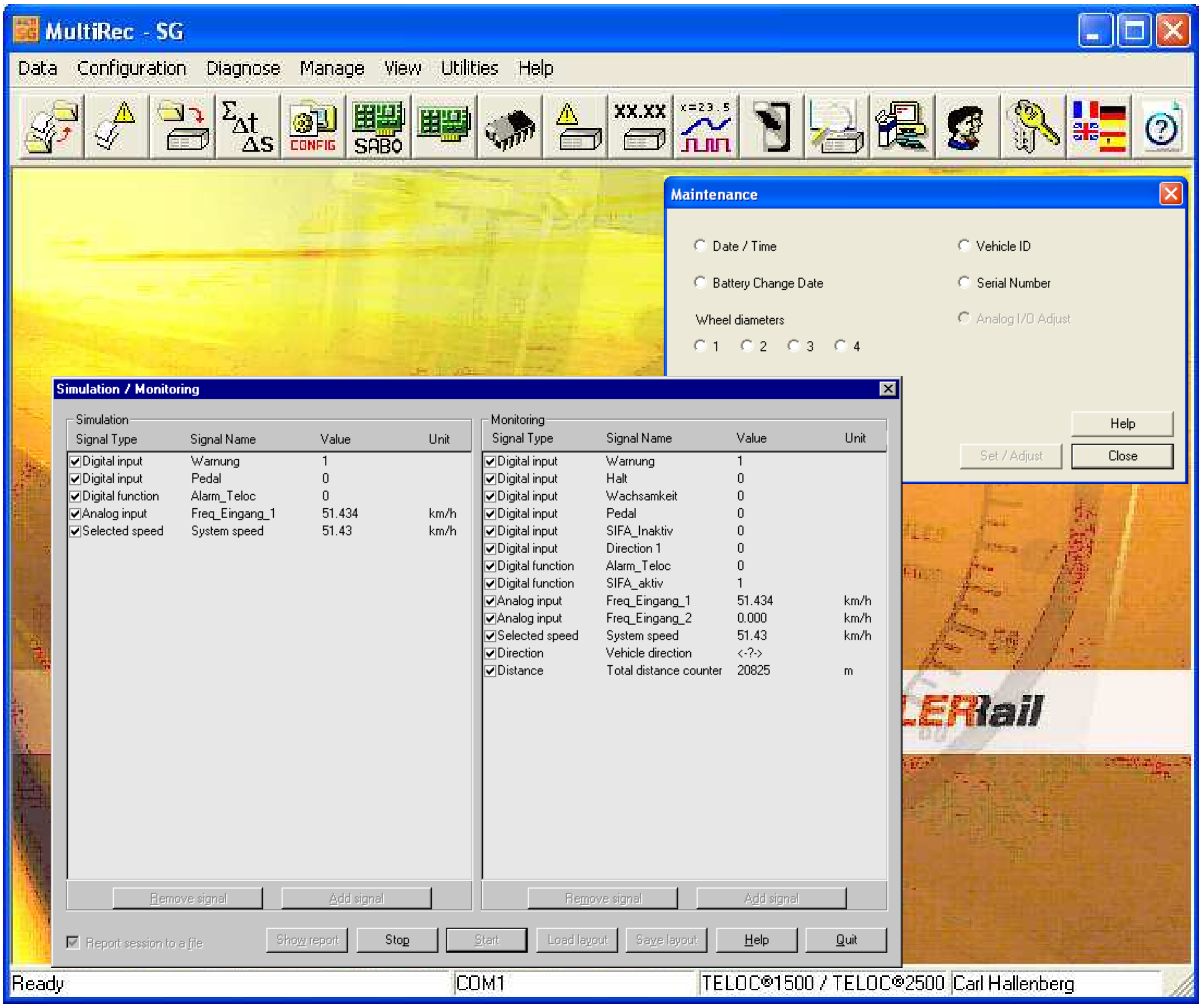
The following information must be configured for each analog input:

- Mnemonic associated to each signal
- Units of each signal
- DBR for each signal

5.7.8 Service interface

In connection with the TELOC® product family HaslerRail offers the Windows based service software Hasler®MultiRec-SG to maintain train and TELOC® data.

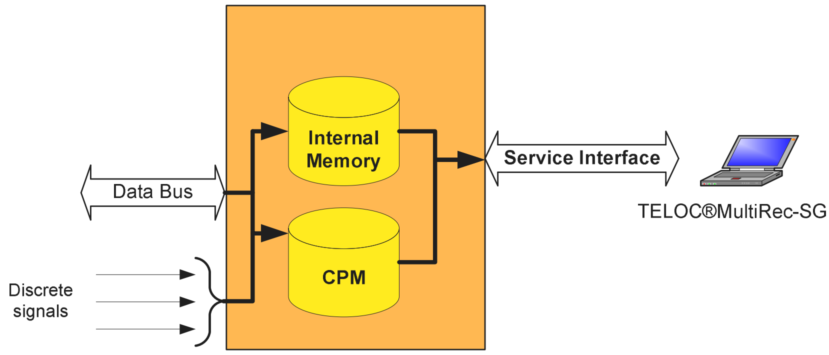
Through the service interface the TELOC® software (application SW, boot SW, etc.) and the customer specific configuration of the recorder can be uploaded with the Hasler®MultiRec-SG service unit tool. This tool allows also adjusting the operating parameters (vehicle ID, wheel diameter, date & time, etc. if necessary). The MultiRec-SG tool offers also the possibility to simulate and monitor signals for commissioning and maintenance purposes.



The download of the data is done over the service interface (USB or Ethernet). The data can be represented and analyzed then with the evaluation software TELOC®EVA.

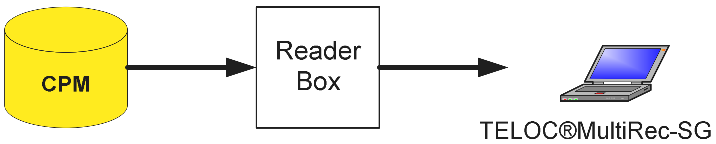
5.7.9 Data recording in Crash Protected Memory

The data can be recorded both in the internal memory and in the CPM according to the customer specific configuration (to be defined). Thus the CPM is a copy of the internal memory located on the main processor board COREB.



5.7.10 Data download from Crash Protected Memory

If the TELOC® is defect after an accident, so that the data cannot more be downloaded over the equipment and service interface, the data must be read directly from the CPM with the service unit software (Hasler®MultiRec SG) through an intermediate box and later the selected data can be evaluated with the TELOC®EVA tool. Since the CPM is inside the TELOC, only HaslerRail can read the data with the reader box (TELOC® should not be opened by the customer).



5.7.11 Data download via USB stick

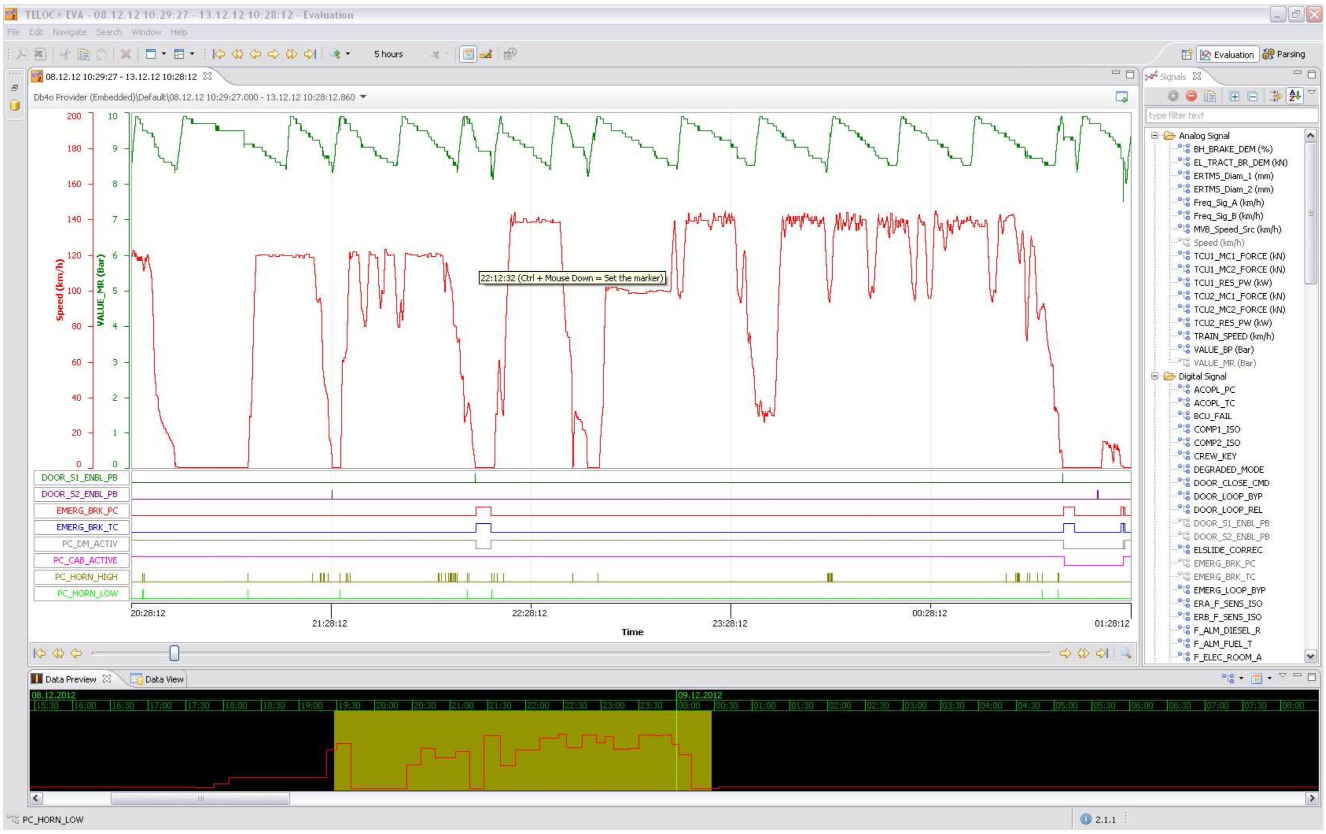
Download can be evaluated afterwards with the TELOC®EVA tool.

5.7.12 Evaluation Software

Furthermore HaslerRail offers TELOC®EVA evaluation software, which is JAVA based, for the evaluation and analysing of recorded data.

Furthermore HaslerRail offers TELOC®EVA evaluation software, which is based on JAVA, for the evaluation and analysing of recorded data.

With this evaluation Software there is the possibility to export the data on PDF and excel.



ATTACHMENT 2. APPLICATIONS FOR DEVIATION OF PRODUCT

APPLICATION FOR DEVIATION OF PRODUCT		ID:	001	Rev.: A00
REQUEST OF DEVIATION OF PRODUCT ORIGINATED BY				
NAME:	Ruedisueli Josef			
POSITION:	Technical Expert			
DEPARTMENT:	Sales			
REQUEST:	HaslerRail/CAF proposes partial compliance with certain IEEE1482.1 Standard clauses with its corresponding alternative or justification. HaslerRail/ CAF request the City to consider this alternatives or justifications.			

CAUSE:

Technical Specification of Cincinnati. T.S. 13.8.1

Independent of the monitoring and diagnostic system described in Section 9.7, each car shall be provided with a fully electronic data recorder system which shall store times, speeds, distances traveled, and both analog and digital events as described further below. The event recorder shall be a self-contained unit with data storage and retrieval capabilities as described in Section 13.12.2. Unless explicitly stated otherwise, the event recorder shall comply with the requirements of IEEE 1482.1, "Standard for Rail Transit Vehicle Event Recorders.

Technical Specification of Cincinnati. T.S / 13.8.2

Signal sampling and recording rates shall comply with IEEE Std 1482.1.

JUSTIFICATION:

The deviations below are considered for the TELOC equipment. The Crash Protected Memory (CPM) is fully compliant with 4.5 Crashworthiness requirements of the IEEE 1482.1 Standard.

IEEE 1482.1 – 4.2 : Sampling rate is 20ms. In order to save memory space not all signals are recorded every second. TELOC® is an "event recorder" and records every significant change of a signal (=event) plus periodically the whole set of signals (as so-called "reference blocks").

IEEE 1482.1 – 4.3.1 a) No verification test whilst running the program. Program (Boot and Application SW) are stored in Flash memories. The Event Recorder implements a watchdog functionality integrated in the real-time operating system (VRTX) so there is a constant monitoring functionality rendering a self-test on demand unnecessary.

IEEE 1482.1 – 4.3.1 c) A RAM test is not done periodically to avoid corruption in memory space. The NOR memory technology the TELOC-1500 still uses is relatively old and due to the much lower memory density compared with today's memories it is less sensitive to external influences. And again, the proper software functionality is assured by the use of a watchdog.

IEEE 1482.1 – 4.3.5 c) The isolation test is carried out according to Standard EN50155, i.e. 1500Vac/50Hz/60sec.
Each digital input is opto isolated and they are organised in groups of 4 inputs with a common return. Analogue inputs are galvanically isolated, but not isolated from each other on the same board (4 inputs per board). The frequency inputs can be galvanically isolated.

IEEE 1482.1 – 4.3.5 e) Test is made according to Standards EN 50121-3-2:2006 and BRB/RIA Specification No. 12, 1984.

IEEE 1482.1 – 4.3.5 f) Compliant for digital inputs.
Analogue inputs signals must be converted to max ±10V.
Frequency inputs signals must be limited to ca. 60V.

DEVIATION ID-001 ACCEPTED BY MEANS OF CINCAF0082

<table>
<tr><td>APPLICATION FOR DEVIATION OF PRODUCT</td><td>ID:</td><td>002</td><td>Rev.: A00</td></tr>
<tr><td colspan="4">REQUEST OF DEVIATION OF PRODUCT ORIGINATED BY</td></tr>
<tr><td>NAME:</td><td colspan="3">Ruedisueli Josef</td></tr>
<tr><td>POSITION:</td><td colspan="3">Technical Expert</td></tr>
<tr><td>DEPARTMENT:</td><td colspan="3">Sales</td></tr>
<tr><td>REQUEST:</td><td colspan="3">Follow maximum toxic gas release limits of EN5510-2 instead of BSS-7239 for materials of Event Recorder.</td></tr>
<tr><td colspan="4">CAUSE:

Technical Specification of Cincinnati. T.S. 16.14.5
All materials used in the car construction, except for materials used in small parts (such as knobs, rollers, fasteners, clips, grommets, and small electrical parts) that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall be tested for toxicity using Boeing Specification Support Standard BSS-7239. Materials shall meet the following maximum toxic gas release limits (ppm) as determined per BSS-7239.
Carbon Monoxide (CO) 3500 ppm
Hydrogen Fluoride (HF) 200 ppm
Nitrogen Dioxide (NO2) 100 ppm
Hydrogen Chloride (HCL) 500 ppm
Hydrogen Cyanide (HCN) 150 ppm
Sulfur Dioxide (SO2) 100 ppm</td></tr>
<tr><td colspan="4">JUSTIFICATION:

The toxic gas release has been tested for all board materials according EN5510-2 instead of BSS-7239.
The test results are comparable (below) with the values requested in BSS-7239 Standard.</td></tr>
</table>

Test results (average values)

Specimen mass:

Initial mass (g)	19.3
Final mass (g)	12.7
Mass loss (g)	6.6

Burning behaviour:

Time to ignition (s)	186
Time to extinguishment (s)	381

Gas analysis:

4 min sampling point

Gas component	ppm	mg/m^3	mg/g
CO_2	4786	7694	203
CO	1084	1109	29
HF	n.d.	n.d.	n.d.
HCl	38	50	1
HBr	100	295	8
HCN	38	38	1
NO_2	30	51	1
SO_2	n.d.	n.d.	n.d.
CIT_G (4 min):	0.53		

8 min sampling point

Gas component	ppm	mg/m^3	mg/g
CO_2	8099	12884	341
CO	1187	1202	32
HF	n.d.	n.d.	n.d.
HCl	71	93	2
HBr	22	63	2
HCN	35	34	1
NO_2	41	69	2
SO_2	n.d.	n.d.	n.d.
CIT_G (8 min):	0.43		

DEVIATION ID-002 ACCEPTED BY MEANS OF CINCAF0042

APPLICATION FOR DEVIATION OF PRODUCT	ID:	003	Rev.: A00

REQUEST OF DEVIATION OF PRODUCT ORIGINATED BY

NAME:	Ruedisueli Josef
POSITION:	Technical Expert
DEPARTMENT:	Sales
REQUEST:	Use event recorder T3 according to EN50155.

CAUSE:

Technical Specification of Cincinnati. T.S. 16.27.1
All electronic control equipment shall comply with the requirements of IEC 60571 “Electronic Equipment Used on Rail Vehicles, Class TX”, IEC 61287-1 “Power Converters installed on board rolling stock”, or IEEE Standard 16 “IEEE Standard for Electrical and Electronic Control Apparatus on Rail Vehicles”, latest revision, or such other standard approved by the City.

JUSTIFICATION:

Considering the following statements :

- That event recorder is going to be installed in an electrical cabinet inside the tram ,
- that the low limit temperature is 7 degress apart of the lowest registered temperature in Cincinatti (historical extreme) and ,
- that the average temperature over the last 30 years, for each month of the year, the coldest temperature is only 19ºF (-7ºC) and the warmest temperature is 84.2ºF(29ºC).

the temperature range for the event recorder : T3 (ambient temperature -25C to 70°C) should ensure availability of the event recorder.

TELOC complies with EN50155 which corresponds to IEC60571 standard, as can be seen in the extract of the document attached.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

RAILWAY APPLICATIONS – ELECTRONIC EQUIPMENT USED ON ROLLING STOCK

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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6) All users should ensure that they have the latest edition of this publication.
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8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60571 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

International Standard IEC 60571 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

This third edition cancels and replaces the second edition issued in 1998 and its amendment 1 (2006). It constitutes a technical revision.

The main technical changes with regard to the previous edition are as follows:

a) In 4.1.2, Table 1 has been modified according to IEC 62498-1. Additional explanation about the aim of this table is mentioned as notes.

b) In 5.1.1.1, "32 V", "36 V", "64 V" and "87 V" have been added as the nominal voltage of equipment according to IEC 60077-1.

c) In 5.3 and 5.5.7.2.1 (Figure 1), the word "interference" has been replaced by "disturbance" that is more appropriate because "disturbance" is the cause of "interference".

d) In 12.2.7, "max" of the test waveform duration D has been replaced by "min" in the table in Figure 2. Specifying "min" can be expected to derive the duration time D longer than 1 s but quite near 1,0 s in almost all actual business case. On the other hand, specifying "max" may cause unnecessarily shorter D than 1,0 s.

e) In 5.1.1.2, "0,7 U_n" has been changed to "k U_n" and some examples for Nickel-cadmium battery and Lead-acid battery are given as NOTE.

f) Subclause 12.2.9, Radio frequency test, has been divided into 12.2.9.1, Radio frequency immunity test, and 12.2.9.2, Radio frequency-emission test.

The text of this standard is originally based on EN 50155. It was submitted to the National Committees for voting under the Fast Track Procedure.

The text of this standard is based on the following documents:

FDIS	Report on voting
9/1711/FDIS	9/1735/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

DEVIATION ID-003 ACCEPTED BY MEANS OF CINCAF0082

APPLICATION FOR DEVIATION OF PRODUCT	ID:	004	Rev.: A00

REQUEST OF DEVIATION OF PRODUCT ORIGINATED BY

NAME:	Ruedisueli Josef
POSITION:	Technical Expert
DEPARTMENT:	Sales
REQUEST:	Use EN50155 insulation tests for event recorder instead of IEEE Standard 16

CAUSE:

Technical Specification of Cincinnati. T.S. 15.6.10
All electrical and electronic assemblies shall be subjected to an insulation resistance and a high potential test in accordance with the requirements of Section 15.2.

JUSTIFICATION:

TELOC is not tested to IEEE Standard 16 concerning High Voltage insulation test requirements, according to which, the limits for this project should be (1000Vac / 500 Vdc) (considering the event recorder nominal circuit voltage is below 90V). We confirm TELOC complies with EN50155 insulation test limits (1500Vac 500VDc) which corresponds to IEC60571 standard (as can be seem in the extract of the document attached). Limit values for EN50155 are higher than IEEE Standard 16, accordingly the purpose of the test should be satified.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

RAILWAY APPLICATIONS –
ELECTRONIC EQUIPMENT USED ON ROLLING STOCK

FOREWORD

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9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60571 has been prepared by IEC technical committee 9: Electrical equipment and systems for railways.

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a) In 4.1.2, Table 1 has been modified according to IEC 62498-1. Additional explanation about the aim of this table is mentioned as notes.

b) In 5.1.1.1, "32 V", "36 V", "64 V" and "87 V" have been added as the nominal voltage of equipment according to IEC 60077-1.

c) In 5.3 and 5.5.7.2.1 (Figure 1), the word "interference" has been replaced by "disturbance" that is more appropriate because "disturbance" is the cause of "interference".

d) In 12.2.7, "max" of the test waveform duration D has been replaced by "min" in the table in Figure 2. Specifying "min" can be expected to derive the duration time D longer than 1 s but quite near 1,0 s in almost all actual business case. On the other hand, specifying "max" may cause unnecessarily shorter D than 1,0 s.

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- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

DEVIATION ID-004 ACCEPTED BY MEANS OF CINCAF0042

APPLICATION FOR DEVIATION OF PRODUCT	ID:	005	Rev.: A00

REQUEST OF DEVIATION OF PRODUCT ORIGINATED BY

NAME:	Iñigo Pinilla
POSITION:	Technical Expert (CAF)
DEPARTMENT:	System Engineering
REQUEST:	Use IP40 for TELOC instead of NEMA Type 12 for TELOC.

CAUSE:

Technical Specification of Cincinnati. T.S. 14.4.1
All exterior and interior equipment enclosures shall be constructed to NEMA Type 4 and NEMA Type 12 standards, per NEMA 250 Enclosure standards, respectively and as described below. Where conflicts exist, this document shall prevail.

JUSTIFICATION:

Considering the following statements :

- that event recorder is going to be installed in an electrical cabinet inside the tram ,
- that the it needs ventilation (accordingly certain airflow is needed)
- that the TELOC belongs to a product family which has been widely used in commercial service without any issues of water or dust ingress.(service proven product)

the level of protection :IP40 should ensure availability of the event recorder.

DEVIATION ID-005 ACCEPTED BY MEANS OF CINCAF0042

--- END OF DOCUMENT ---

APPENDIX 13.6

EVENT RECORDER FUNCTIONAL DESCRIPTION

ISSUE CONTROL

ISSUE	REASON	DATE
-	First issue	17/FEB/2014

DISTRIBUTION

Miguel Artigas (Technical Project Manager)
Ignacio Olivera (Project Manager)
City of Cincinnati

Prepared by:	**Revised by:**	**Approved by:**
Name: Iñigo Pinilla	**Name:** Victor Agullo	**Name:** Miguel Artigas
Signature:	**Signature:**	**Signature:**
Date: 17/FEB/2014	**Date:** 17/FEB/2014	**Date:** 17/FEB/2014

INDEX

1 PURPOSE

The purpose of this document is to present, for City of Cincinnati review and approval, the Functional Description of the Event Recorder of the Cincinnati Streetcar.

2 FUNCTIONAL DESCRIPTION

Apart from data recording (described in Q.41.91.163.00 – Technical Description of Event Recorder), the event recorder equipment performs different functionalities that are integrated in the train circuits so as to join the train global performing. In the sections below, these functionalities are described.

4.1. Speedometer

For detailed information of the speedometer refer to the attachment in Section 3.

4.2. No motion detection control

The event recorder generates a speed zero wired digital signal that is used, in series with one COSMOS (MDS) digital output, to generate the Null Speed train line.
The deactivation of this train line can be bypassed from the enabled cabin in case an error in the event recorder is detected.
The event recorder Speed Zero signal is set to 0 when the train speed exceeds 4 km/h (2.49 mph) and is set to 1 when the speed goes under 2 km/h (1.24 mph).

4.3. Driver Safety Device (DSD)

The driver safety device (dead man module) performs the vigilance of the driver status by means of a predefined sequence that the driver shall follow while driving.

The DSD module takes into account the following inputs of the driver in the enabled cab:

- Driver vigilance control system in the master controller.
- MB/FSB position of the master controller.

Starting condition: the vigilance starts as soon as the equipment is supplied with power, provided the safety off signal is not active (digital wired input to the event recorder that allows stopping the vigilance control).

The DSD module generates the following outputs during the vigilance sequence:

- Warning lamp and buzzer: these outputs correspond to the warning if the driver is not following the sequence. The lamp and buzzer are located in the cab desktop.
  When the streetcar is not in motion, the train circuit annuls the buzzer output so as not to disturb the driver during a possible long manoeuvre at zero speed.
- Emergency brake: these outputs are closed if the conditions that permit driving are correct and the equipment is operative. The dead man module will open the event recorder emergency brake outputs in case the warnings, during the dead man control sequence, causes no reaction in the driver actuation.

Reset condition of the emergency outputs: the event recorder dead man module will keep these outputs open until the master controller is put to MB or FSB position. The closing of the outputs is possible before the streetcar is stopped.

Integration of the event recorder emergency brake outputs in the train: in case the emergency outputs are open, train Full Service Brake will be applied These outputs can be bypassed from the enabled cabin in case an error in the event recorder is detected (streetcar needs to be stopped).

For detailed information of the DSD sequence refer to the attachment in Section 3.

4.4. Roll-back protection

Roll-back protection module of the event recorder allows stopping the streetcar, by opening the event recorder emergency outputs (the same as the dead man module ones), when an incoherence is detected between the train movement direction and the status of the enabled cab direction selector.
As the event recorder modules use the same emergency outputs for any safety function established, their reset conditions and integration in the train remain as described in previous section.
For detailed information of the Roll-back sequence refer to the attachment in Section 3.

4.4. Overspeed protection

The overspeed protection module of the event recorder allows stopping the streetcar, by opening the event recorder emergency outputs (the same as the dead man module ones), when the speed threshold defined is exceed. In this case the threshold is defined to 74 km/h (45.9 mph).
As the event recorder modules use the same emergency outputs for any safety function established, their reset conditions and integration in the train remain as described in previous section.
For detailed information of the Roll-back sequence refer to the attachment in Section 3.

3 ATTACHMENTS

Document	Issue	Date	Generated by
5.2421.122/01T01 Functional Description: CINCINNATI	A01	07.Feb.2014	HASLERRAIL

ATTACHMENT 5.2421.122/01T01 Functional Description: CINCINNATI

Functional Description *TELOC Train Data Recorder*

Project CINCINNATI (TELOC®1500 Safety)

Abstract

This document defines the specific customer functionality

Written	*Remo Spinosi*	*07.02.2014*	**Functional Description: CINCINNATI**		
Reviewed	*Andy Gonzalez*	*07.02.2014*			
Released	*Remo Spinosi*	*07.02.2014*	We reserve all rights in this document and in the information contained therein. Reproduction, use or disclosure to third parties without express prior consent is strictly forbidden. © Hasler Rail AG.	5.2421.122/01T01	1/8
Version	**A01**				

Version History

Version	Modifications/Comments	Signature	Date
A00	First Issue based on document	Remo Spinosi	15.08.2013
A01	Minor changes according Customer	Remo Spinosi	07.02.2014

Table of contents

1. INTRODUCTION

1.1 Purpose

The purpose of this document is to explain the customer functionality of the Event Recorder System supplied by HaslerRail to be installed in the train on the project J0226B of CINCINNATI.

1.2 References

		Document ID
[1]	System specifications – Project J0226B	5.2421.122/01N01
[2]	Release Note – Project J0226B	5.2421.122/01R01
[3]	Technical Description	5.2421.122/01V01

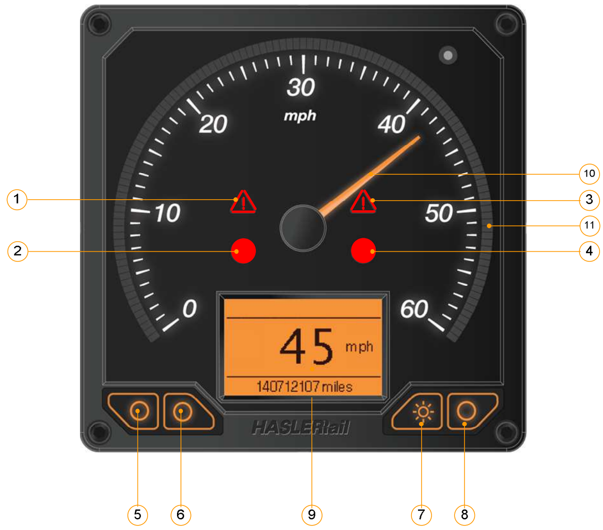
Manuals:

[4]	Manual TELOC®1500	5.0300.085
[5]	TELOC Safety description	5.0300.089
[6]	Hasler® MultiRec-SG Guide	5.0300.048
[7]	Hasler® MultiRec-SG Install	5.0300.043
[8]	Manual TELOC® EVA	5.0300.045

1.3 Definitions and Acronyms

COREB	Processor Board Rev. B
DAIOC	Digital Analogue Input Output Board
DATRA	Data transfer Board
HW	Hardware
IOCOB	Interface Board Rev. B
LTM	Long Term Memory
LCD	Display Internal
POSUE	Power Supply Board Rev. E
REBOB	Relay Board Rev. B
STM	Short Term Memory
SW	Software
TELOC	Train-borne data recording unit (brand name)
TELOC®EVA	TELOC data evaluation software tool
Hasler®MultiRec-SG	TELOC service software tool
USB	Universal Serial Bus

2. SPEED INDICATOR



1 : Led A (Triangle)	Switch ON if a Internal error on Speedo occurs
2 : Led C	Activation occurs trough MVB
3 : Led B (Triangle)	Switch ON if a Feedback Error is detected Switch ON if a Speed > 45.9 mph (74 km/h) Switch OFF if the same reset condition used for Deadman and Rollback are complied.
4 : Led D	Activation occurs trough MVB
5 : Speedo test (Button A)	By pressing this button, an internal test on the Speedo will be started. All lamps will be activated, the Display shown a Speed and the Pointer will also react on the same Speed shown on the display.
6 : Button B	Not used in this Project
7 : Background Light (Button C)	By pressing this button the Background light can be adjusted, after a switch Off of the Speedo, the Backlight level returns to its default.
8 : Button D	Not used in this Project
9 : Display	Following values are shown on the Display : - Speed in miles - Total miles Counter
10 : Pointer	The pointer show the real Speed of the Train.
11 : Led-Ring	The ring show the “*PLC_Limited_Speed*“ *coming from MVB*

3. SAFETY FUNCTIONS

3.1 Safety off

The Deadman function shall be switched off if the vehicle is in Standstill and by generating a "1" on the **Vigilance_Byp** input, the vigilance system is deactivated.
All other safety-related functions remain fully active.

3.2 Visual warning

The Light (Dm_Lamp) will be activated as soon the condition of the DM sequence will be true.
This condition depends on time and the MB/FSB Position signal.
Will be on after 1 second
The Lamp will switch off when activities on the MB/FSB Position or Driv.Vig are recognized.

3.3 Acoustic warning

The Buzzer (Dm_Buzzer) will be activated as soon the condition of the DM sequence will be true.
This condition depends on time and the MB/FSB Position signal.
Will be on after 1 second
The Buzzer will switch off when activities on the MB/FSB Position or Driv.Vig are recognized.

3.4 Speed difference

This safety function activates the MVB signal Taco Diff when a speed difference between the 2 speed generators is detected.
In this project the maximal permitted speed different is: 3.1 mph and an Emr_Brk will be applied.

3.5 Speed indicator speed feedback

The Speedo has a SIL2 safety level, for this reason if the actual speed that come from the speed generator is different that the speed indicated on the speed display, the Lamp B on the Speedo will light and two signal where sent trough MVB (SpeedInFail_C1 and SpeedInFail_C2).
In this project the maximal permitted speed different is: 3.1 mph
The defined time is: 10 s

3.6 Zero speed

The contact is closed when the speed drops below 1.24 mph. When the vehicle accelerates above 2.49 mph, the contact is opened again.
This contact can be used to permit or prevent the opening of the doors.

3.7 Speed thresholds (over speed)

The TELOC control the Maximal permitted speed on the System. In this project the max permitted speed is 45.98 mph (74 km/h), after trespassing this threshold the EMR_BRK will be active, the brake returns inactive when the same reset condition used for Deadman and Rollback are complied.

3.8 Emergency brake

The Emergency Brake will be set (SABO emergency outputs will be open) when any of the following events occur:

- The DM sequence has not been respected.
- Roll-back protection has been activated.
- The internal Sabo Safety control recognize a difference in the speed measurements (one of the generators is defect) and actuates the emergency brake. In this project the brake is applied when a difference of more than 3.1 mph is read during at least 10 seconds.
- Over temperature of the Safety board is detected.

3.9 Dead man function

3.9.1 Description

The automatic vigilance device serves as an automatic train control device on track as well as a driver monitoring device during operation. It constantly monitors the driver's ability to react by having to reset a cycle, triggered by configurable criteria. If the cycle is not resetting, an automatic brake application is triggered after one or more alarm levels.

The DM module's functioning Control Logic can basically be described as follows:

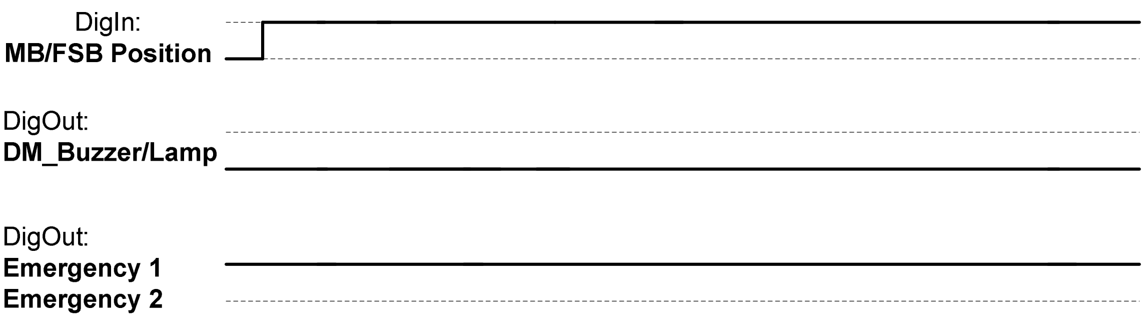
In order for the Deadman emergency not to be activated (SABO emergency outputs will be open),the driver must press a certain mechanical device ;this mechanical device generates a discrete electric signal, which is an input to the DM module.

The engine driver can release the mechanical device for a certain period of time.
If this period of time has elapsed, an acoustic signal will alert the driver. If the driver does not press the mechanical device, after another period of time has elapsed, the Deadman emergency will be activated, (SABO emergency outputs will be open).
Once the DM module has activated the emergency and opened the brake loop, it will reset itself when the conditions below are met.

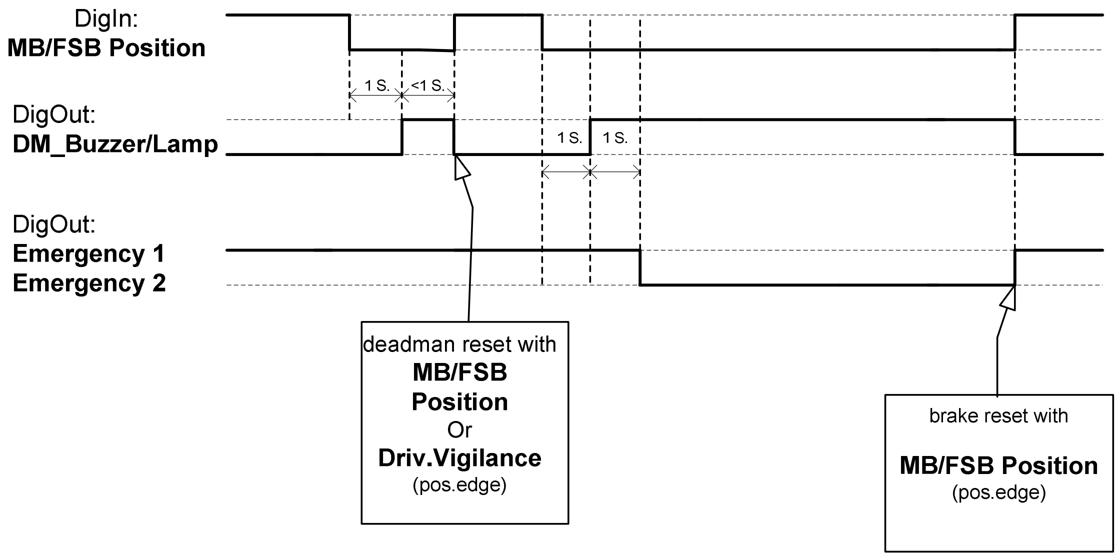
- Change of state in the MB/FSB_Position signal.

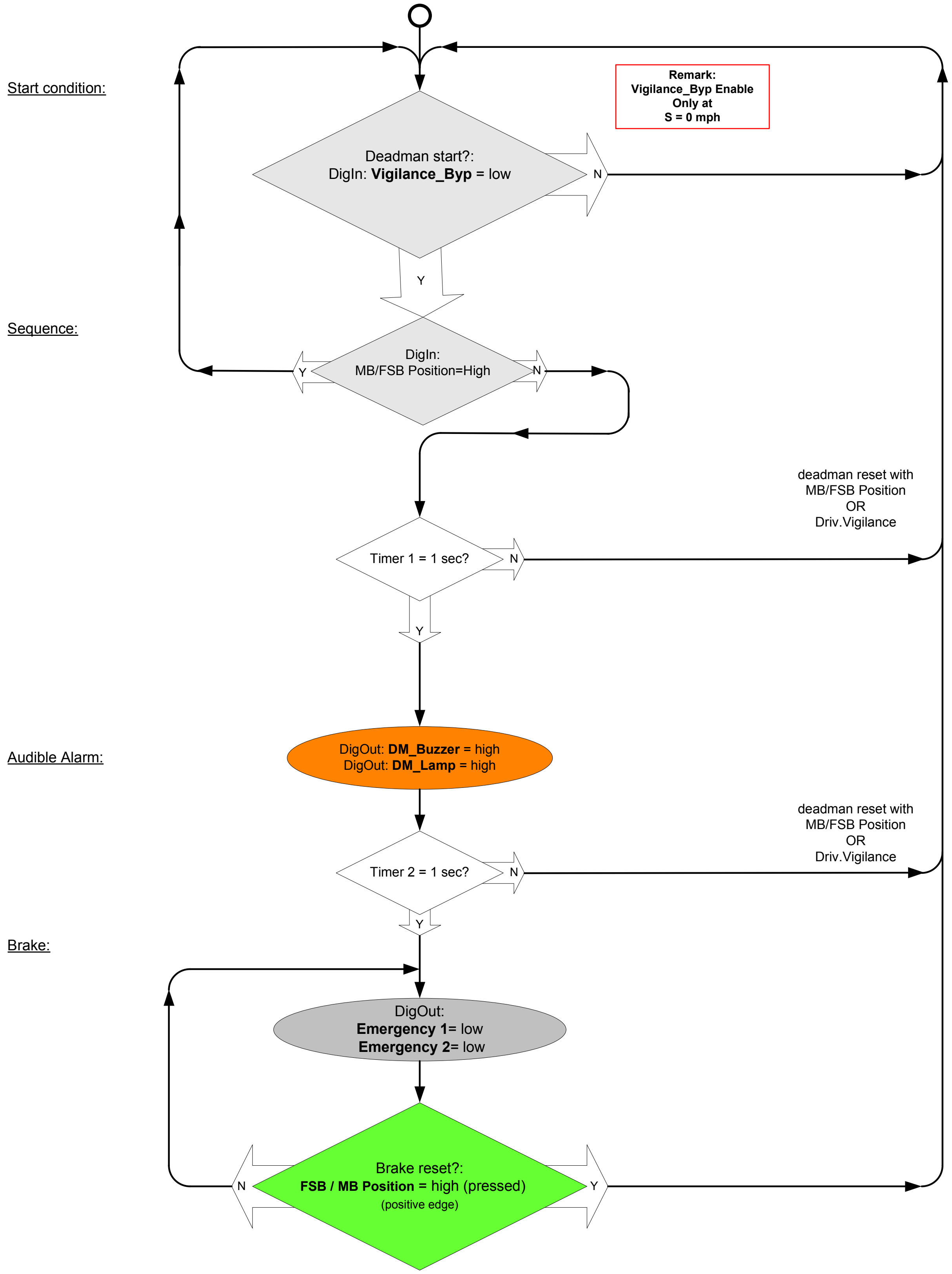
3.9.2 Dead man sequence

Sequence with DM PushButton Pressed

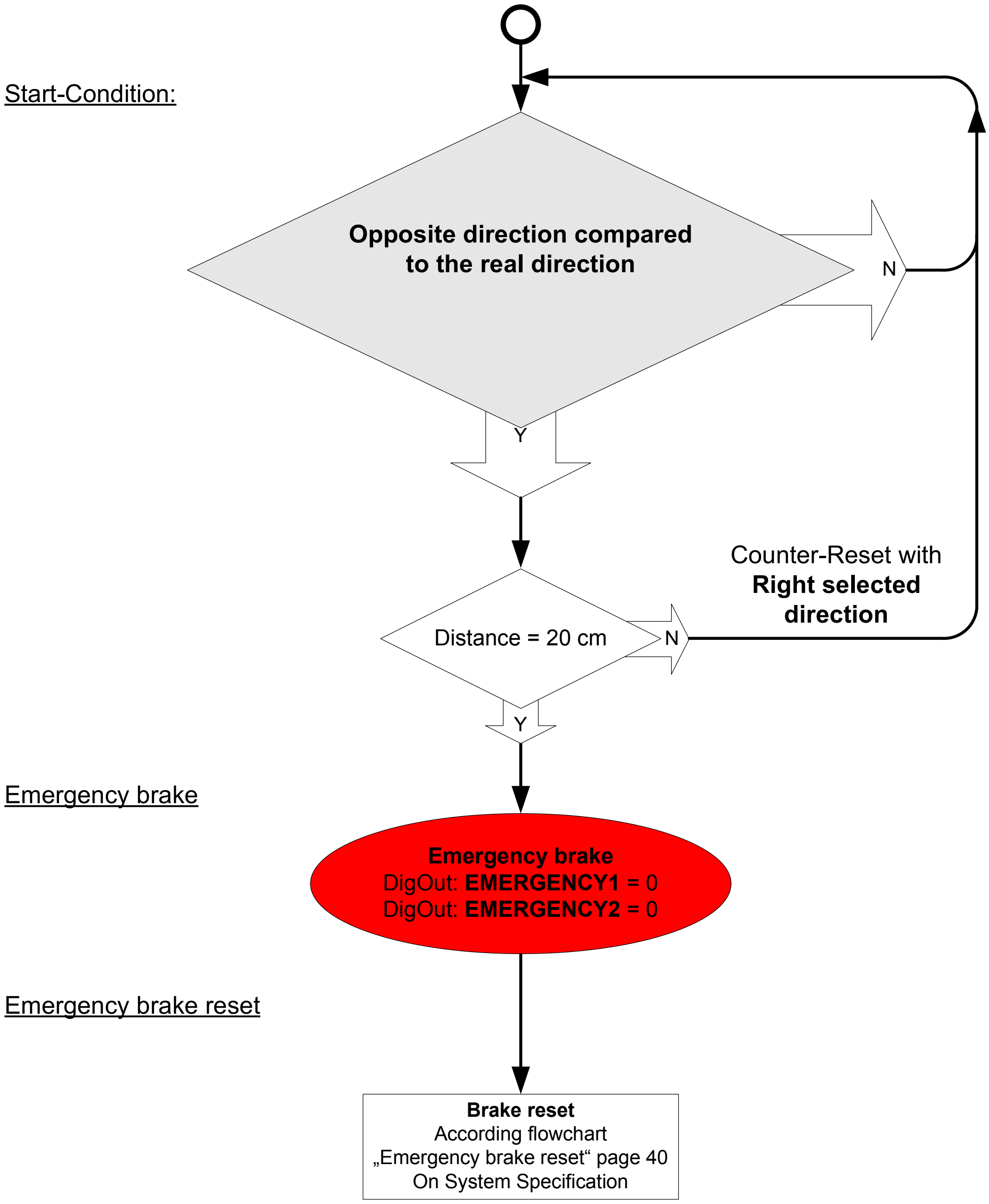


Sequence with DM PushButton not Pressed




Start condition:
Sequence:
Audible Alarm:
Brake:
Remark:
Vigilance_Byp Enable
Only at
S = 0 mph
Deadman start?:
DigIn: Vigilance_Byp = low
N
Y
DigIn:
MB/FSB Position=High
Y
N
deadman reset with
MB/FSB Position
OR
Driv.Vigilance
Timer 1 = 1 sec?
N
Y
DigOut: DM_Buzzer = high
DigOut: DM_Lamp = high
deadman reset with
MB/FSB Position
OR
Driv.Vigilance
Timer 2 = 1 sec?
N
Y
DigOut:
Emergency 1= low
Emergency 2= low
Brake reset?:
FSB / MB Position = high (pressed)
(positive edge)
N
Y

3.10 Rollback protection



The Rollback protection is integrated into SABOA.

The control monitors the driving direction of the vehicle and compares the detected direction to the target driving direction selected with the selector switch.

If the detected driving direction does not match the target driving direction is detected, then after a rolling distance of 0.2 m, the Emergency Brake will be set (SABO emergency outputs will be open)".

--- END OF DOCUMENT ---

APPENDIX 14.1

COMMUNICATION INTERFACES

ISSUE CONTROL

ISSUE	REASON	DATE
-	First issue	28/FEB/2013

DISTRIBUTION

Prepared by: **Name:** Oscar Aldana **Signature:** **Date:** 28/02/2012	**Revised by:** **Name:** Victor Agulló **Signature:** **Date:** 28/02/2012	**Approved by:** **Name:** Miguel Artigas **Signature:** **Date:** 28/02/2012

INDEX

1. INTRODUCTION AND SCOPE

The Cincinnati streetcar project belongs to the common and general bus architecture URBOS 3, described in the document [Ap.5].

This document defines the particular details that the Cincinnati streetcar project shows compared to the general URBOS AXL bus architecture.

The schematic of CIS documents for URBOS AXL projects is shown in Figure 1.

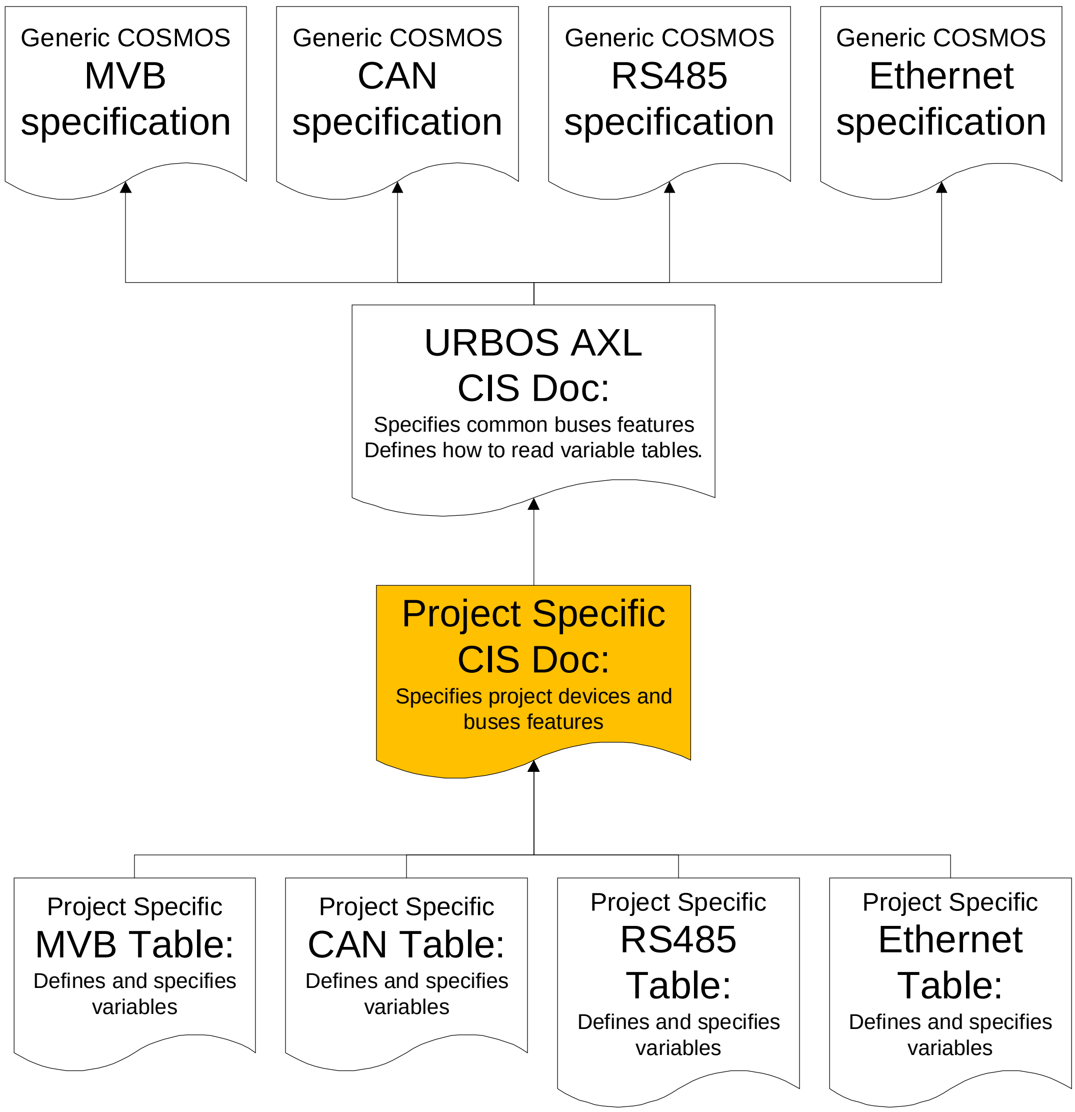


Figure 1.- CIS document relations

2. ABBREVIATIONS AND DEFINITIONS

- CIS Communication Interfaces Specification
- TCN Train Communication Network
- TCMS Train Control and Monitoring System
- MVB Multifunction Vehicle Bus
- WTB Wire Train Bus
- CAN Controller Area Network
- CRC Cyclic Redundancy Check
- PLC Programmable Logic Control (Vehicle Control running in TCMS)
- EMD Electrical Middle Distance
- MD Message Data
- PD Process Data
- LSB Least Significant Bit
- MSB Most Significant Bit
- Offset Bit or variable position, respect to the structure where is located, according it is read in English from left to right and from top to bottom, according to TCN norm (IEC 61375-1 section 2.4.2.4).
- CCU Central Control Unit (TCMS)
- HMI Human Machine Interface (TCMS)
- GW-MVB Gateway Vehicle Bus (TCMS)
- TCU Traction Control Unit
- BCU Brake Control Unit
- DCM Desk Control Module
- EVR Event Recorder

- HVAC Heat, Ventilation & Air Conditioning
- PIS Passenger Information System
- CCTV Closed Circuit Television

3. APPLICABLE DOCUMENTS

The Bus and Communication interfaces specifications are classified depending on the Bus type within the following generic COSMOS documents:

Reference	CAF Code	Ed.	Title
[Ap.1]	Q.41.98.102	-	COSMOS – MVB table
[Ap.2]	Q.41.98.103	-	COSMOS – CAN table
[Ap.5]	Q.23.98.101	-	URBOS 3 Communication Interfaces specification

4. BUS ARCHITECTURE

The Cincinnati streetcar project has a bus architecture based on a backbone bus of MVB type with devices connected directly to it. Other devices are connected to other kind of buses:

- CAN bus
- Ethernet bus
- RS485 bus

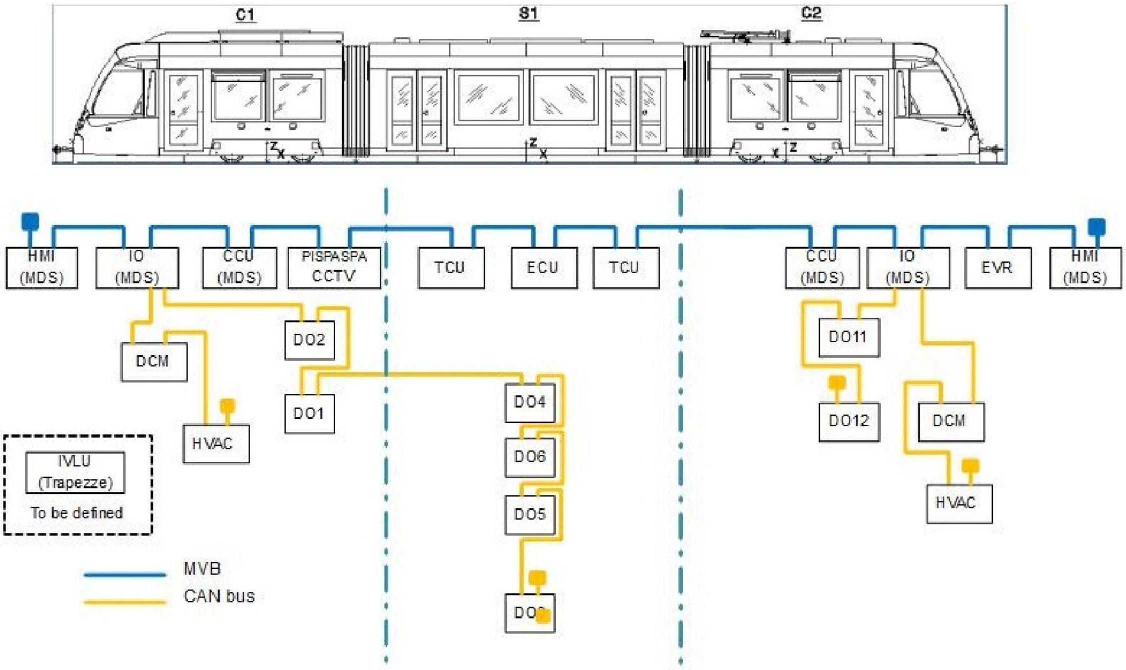


Figure 2.- Cincinnati streetcar MVB – CAN Bus architecture (3 cars)

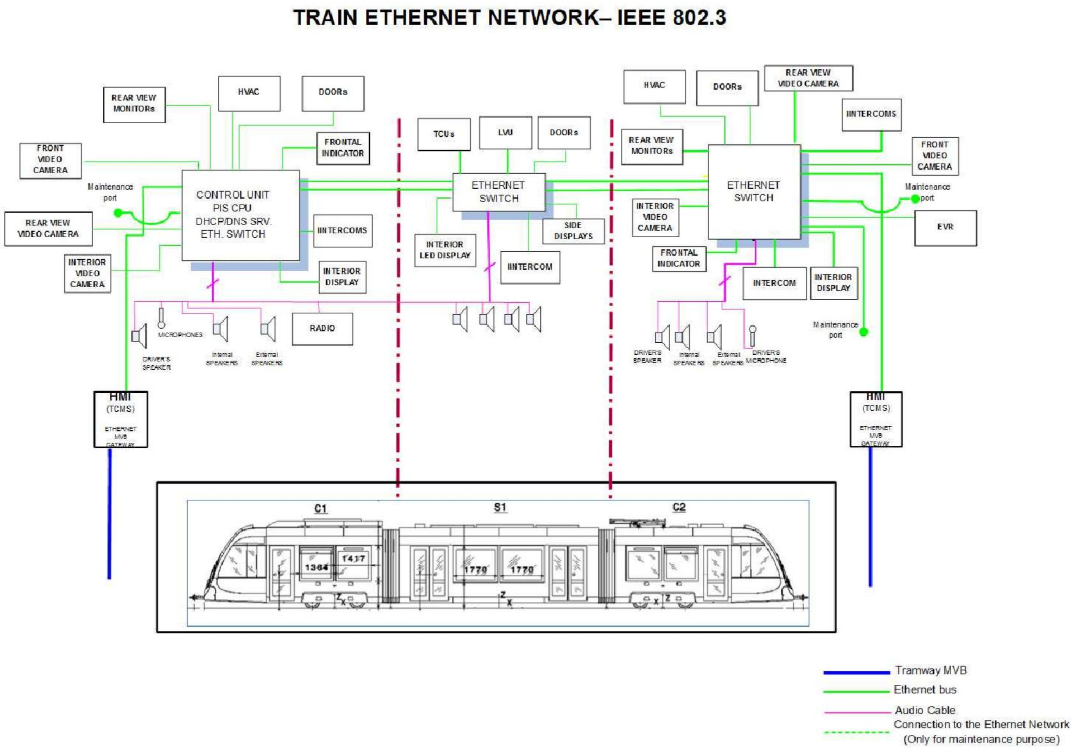


Figure 3.- Cincinnati streetcar Ethernet bus architecture (3 cars)

5. MVB BUS

List of devices connected to the MVB bus:

Node	NodeAdd	Comment
CCU_C1	0x010	MVB Central Control Unit Cab1
CCU_C2	0x012	MVB Central Control Unit Cab2
HMI_C1	0x040	TCMS Cab1 control display
HMI_C2	0x050	TCMS Cab2 control display
TCU_C1	0x080	Traction Control Unit C1 car
TCU_C2	0x090	Traction Control Unit C2 car
EVR	0x068	Event Video Recorder
PPP	0x0F0	PPP Control Unit
IO1_C1	0x100	IO TCMS Module C1 car
IO1_C2	0x200	IO TCMS Module C2 car
ECU	0x060	Electrical control Unit for leveling

6. CAN BUS

There are two separate CAN buses in a 3 module tram. This list shows the devices connected to one CAN bus. The addresses are repeated for the rest of CAN buses:

Node	NodeAdd	Comment
DCM	0x02	Desk Control Module
SHVAC	0x03	Saloon HVAC
DO01	0x04	Door 1
DO02	0x05	Door 2
DO03	0x06	Door 3
DO04	0x07	Door 4
DO03	0x08	Door 5
DO04	0x09	Door 6
MIM	N/A	TCMS IO module (bus master)

7. ETHERNET BUS

7.1. Network topology and addressing

The Switches in the CU in car C1 and the 24 port Switches in cars S1 and C2 are connected to each other using two twisted pair Ethernet cables, using port trunking, effectively doubling the available bandwidth allowed by a single

cable connection, as well as providing redundancy.

The ports 0 to 3 of each Switch are dedicated to the backbone connection. If both cables connecting two switches are plugged in and in working order, then a bandwidth of 200 Mbps will be available between the two switches.

Each device is connected exactly to a single port, which is not shared with any other device, giving the network a star arrangement, thus minimizing the possible failures due to cabling faults.

The network provides two main functions:

- Distributing in digital format all the audio, video and auxiliary data traffic needed by the SEPSA's System to carry out its function, as well as providing maintenance access to its devices.
- Providing maintenance access to the auxiliary devices (not belonging to SEPSA's System) connected.

Seprate VLANs are not considered necessary.

Each device is assigned an IP address using the DHCP protocol, and a DNS name, with which is addressed by the other hosts on the network. The CPU of the PIS system serves as the DHCP and DNS server.

The systems onboard (maintenance laptops included) will be able to make use of the DNS service to get the IP of the other systems connected to the network if they need it.

The DHCP server will provide information about the available DNS servers.

The network established has a range (in CIDR notation) of 10.0.0.0/8, and uses an internal logic based on the unit/car number in addition to an identifier specific to the host.

The following alphanumeric string will be used as logical identifier:

SYSTEM.CAR.UNIT.STREETCAR

STREETCAR is fixed for all devices .

UNIT is composed by the text string UT followed by two other digits representing the train unit for example UT01 for the train unit number 1.

CAR is one of: C1, S1, C2

SYSTEM is specific to each host, usually a combination of a name, depending on the host type, and optionally a number, if there is more than one device of the same type in the car.

At system boot up, the DHCP 82 server assigns always the same IP addresses to every switch port.

List of devices connected to the Ethernet network for **maintenance purposes**:

Node	Local IP/Hostname	Comment
HMI_C1	10.N.1.161 HMI.C1.UTxx.STREETCAR	TCMS Cab1 control display.
HMI_C2	10.N.2.161 HMI.C2.UTxx.STREETCAR	TCMS Cab2 control display.
PC_C1	10.N.1.150 PC.C1.UTxx. STREETCAR	Service port at Cab 1 (desk RJ45).
PC_C2	10.N.2.150 PC.C2. UTxx. STREETCAR	Service port at Cab 2 (desk RJ45).
HVAC_C1	10.N.1.162 HVAC.C1. UTxx. STREETCAR	Saloon 1 HVAC.
HVAC_C2	10.N.2.162 HVAC.C2. UTxx. STREETCAR	Saloon 2 HVAC.
ECU_S1	10.N.3.163 ECU.S1. UTxx. STREETCAR	Electronic Control Unit. Leveling.
EVR	10.N.2.160 EVR.C2. UTxx. STREETCAR	Event Video Recorder.
TCU_C1	10.N.3.170 TCUC1.S1. UTxx. STREETCAR	Traction Control Unit controlling C1 car. Opt224=0 (connected to P10 in switch S1)
TCU_C2	10.N.3.180 TCUC2.S1. UTxx. STREETCAR	Traction Control Unit controlling C2 car. Opt224=0 (connected to P11 in switch S1)
TCUMon_C1	10.N.3.171 TCUMC1.S1. UTxx. STREETCAR	CPU Monitor Traction Control Unit C1 car. (connected to P10 in switch S1) Opt224=4
TCUMon_C2	10.N.3.181 TCUMC2.S1. UTxx. STREETCAR	CPU Monitor Traction Control Unit C2 car. (connected to P11 in switch S1) Opt224=4
DO01_C1	10.N.1.165 DO1.C1. UTxx. STREETCAR	Door 01 of C1 car.
DO02_C1	10.N.1.166 DO2.C1. UTxx. STREETCAR	Door 02 of C1 car.
DO03_S1	10.N.3.165 DO3.S1. UTxx. STREETCAR	Door 03 of S1 car. (connected to P12 in switch of S1)
DO04_S1	10.N.3.166 DO4.S1. UTxx. STREETCAR	Door 04 of S1 car. (connected to P13 in switch of S1)
DO05_S1	10.N.3.167 DO5.S1. UTxx. STREETCAR	Door 05 of S1 car. (connected to P14 in switch of S1)

Node	Local IP/Hostname	Comment
DO06_S1	10.N.3.168 DO6.S1. UTxx. STREETCAR	Door 06 of S1 car. (connected to P15 in switch of S1)
DO01_C2	10.N.2.165 DO1.C2. UTxx. STREETCAR	Door 01 of C2 car.
DO02_C2	10.N.2.166 DO2.C2. UTxx. STREETCAR	Door 02 of C2 car.

N represents the StreetCar unit.

8. SPECIAL VARIABLES

8.1. Date and Time change

EVR date and time is independent and cannot be changed from any device. The time and date update must be done in the own EVR.

9. LOCATIONS AND IDENTIFIERS

9.1. Doors

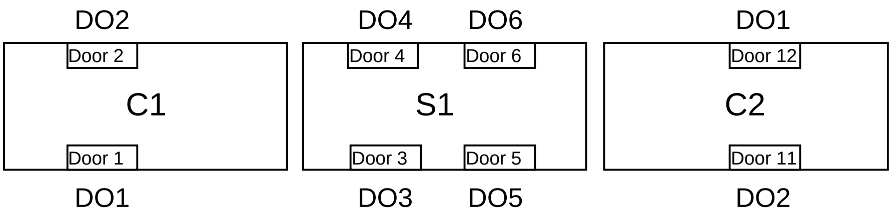


Figure 4.- Cincinnati StreetCar Door Location (3 cars)

9.2. Cameras

CAMERA NAME	CAMERA ID RearCamMon_RUppCabx RearCamMon_RLowCabx	#DNS
CAMARA_INTERIOR_C1	1	
CAMARA_FRONTAL_C1	2	
CAMARA_RETROVISORA_IZQ_C1	3	
CAMARA_RETROVISORA_DCHA_C1	4	
CAMARA_INTERIOR_S11	5	
CAMARA_INTERIOR_S12	6	
CAMARA_INTERIOR_C2	11	
CAMARA_FRONTAL_C2	12	
CAMARA_RETROVISORA_IZQ_C2	13	
CAMARA_RETROVISORA_DCHA_C2	14	
CAMARA_INTERIOR_C12	17	
CAMARA_INTERIOR_C22	18	

APPENDIX 14.2

HMI GUI SPECIFICATION

ISSUE CONTROL

ISSUE	REASON	DATE
-	First issue	24/10/2013
A	Updated PIS Screens. Included virtual controls proposal. Updated Comfort screen	04/JUN/2014
B	Added reverse indication in driving mode.	23/SEP/2014
C	R (Reverse) instead of B (Backwards)	29/OCT/2014
D	Updated Figure 17. Modified driving mode (Wash mode). Updated iconography and maintenance screens. Driver ID is not shown in status bar. Updated date format to MM-DD-YYYY. Updated controls (control screen). Updated events table information. Minimum OCS accepted Voltage 525Vdc. Updated screens. Updated stop request buttons description.	12/MAR/2015

DISTRIBUTION

Miguel Artigas (Technical Project Manager)
Ignacio Olivera (Project Manager)
City Of Cincinnati

Prepared by:	**Revised by:**	**Approved by:**
Name: Oscar Aldana	**Name:** Oscar Sánchez	**Name:** Miguel Artigas
Signature:	**Signature:**	**Signature:**
Date: 12/MAR/2015	**Date:** 12/MAR/2015	**Date:** 12/MAR/2015

INDEX

1. INTRODUCTION

1.1 OBJECT

The object of this document is to specify the functionality that the HMI of the **Cincinnati Streetcar** must fulfil through the various screens which it will display to its users.

The primary user of the HMI is the driver. The basic principles behind the preparation of the HMI screens are the following:

- effectiveness
- efficiency
- satisfaction

Other users of the HMI system are the train maintenance staff and the programmers of the TCMS system, COSMOS (given that the HMI is the primary interface of the COSMOS TCMS system itself). For these system users, various aspects have been considered, such as access restriction, functionality, etc.

As regards the graphics presented in this document, it must be pointed out that the designs are not definitive and that they may undergo changes at the time that they are implemented due to technical reasons.

1.2 SCOPE

The scope of this document is to cover all aspects related to the graphic application that will run on the HMI (belonging to the COSMOS system) of the Cincinnati Streetcar.

Graphic application is hereby understood as the software that, running on the HMI of the COSMOS-TCMS system, shows information to the user organised on various screens. The user can move among the various screens, thereby "navigating" them, by using the touch screen.

This document presents a briefly description of the various ways in which faults and events are shown on the HMI screens and the corresponding recommendations. However, it is not included the specific content of each fault or event, which is explained in the events specification and configuration document ([Ref. 2]).

Therefore, the representations, formats and forms of the warnings that are used on the HMI system are covered by this document, given that they form a part of the interface with the user. However, the specific information to be represented, in addition to all of the possible faults, is outside of the scope of this document. All the information that may appear in this regard, or that may be interpreted in this document, is merely informative and used as an example in order to provide a better understanding of the functionality and formats allowed by the graphic application.

The scope of this document does not cover the rest of the HMI software dedicated to other functions which are done by the TCMS system, such as managing events, communications management, data recording, etc.

1.3 ABBREVIATIONS

CAF	Construcciones y Auxiliar de Ferrocarriles S.A.
CCU	Cosmos Control Unit
COSMOS	Control and Supervision Modular System
HMI	Human-Machine interface (also MMI Man-Machine Interface)
MVB	Multifunctional Vehicle Bus
TCN	Train Communication Network
TU	Streetcar/Train Unit
TCMS	Train Control and Monitoring System
N/A	Not Applicable
HSCB	High Speed Circuit Breaker
ATP	Automatic Train Protection System
DSD	Driver’s Safety Device
ER	Event Recorder
TCU	Traction Control Unit
BCU	Brake Control Unit
SHVAC	Passenger compartment Heating Ventilation and Air Conditioning
PISPASPA	Passenger Information, Passenger Assistance System and Public Address
CCTV	Video surveillance System
DO	Door
PB	Push-Button
CF	Comfort
HV	High Voltage
MIA	Mobility Impaired Accomodation

2. RELATED DOCUMENTATION

The following documentation applies:

Reference	Title	CAF Code
[Ref. 1]	TCMS technical description	Q.41.91.162
[Ref. 2]	HMI Event Specification	Q.41.98.212

3. GENERAL DESCRIPTION

3.1 HMI FUNCTIONALY

The HMI is a fundamental part of the COSMOS-TCMS system. For more information of the COSMOS system, see the document [Ref. 1]

The main objective of the HMI of the train is to interact with the user (whether the driver, maintenance staff or programmer). To be precise:

1) To inform the user about the status of the streetcar.

2) To transmit orders from the user to the streetcar.

In order to inform the user about the status of the streetcar, the HMI will provide pertinent information at any given moment, which it obtains through the MVB of the train.

The HMI employs various screens in order to clearly and accurately report the status of the train to the user. Each screen has a different objective and functionality. This separation of functionalities by screens allows providing clearer and more accurate information to the user.

This information also may be used in order to increase reliability due to the fact that it's possible to redound the information of some physical devices.

Movement between the screens can be manual or automatic, in accordance with a series of parameters. The user is thereby provided with the desired information at the right time.

Moreover, the HMI also records the events and provides a record of the variables associated with. This functionality is directed focus on facilitating the streetcar maintenance.

With respect to the second function, transmitting orders from the user to the streetcar, the graphics application of the HMI is capable of including certain orders and sending them to the MVB bus so that they are considered by the control unit of the COSMOS-TCMS system.

By redounding physical pushbuttons at driver's desk with virtual pushbuttons on the HMI screens, the reliability of the streetcar is also increased, since even with a fail in the physical pushbutton the order can be transmitted to the streetcar.

3.2 ARCHITECTURE OF THE HMI

The HMI consists of various internal modules, which are summarised as follows:

- **TFT Touch Screen** that shows the screens to the user, and allows him to interact with the system by touching specific areas of the screen.

- **Virtual Pushbuttons**, represented graphically on the active area of the touch screen. These buttons allow, in an intuitive way, to input orders into the system.

- **MVB and Ethernet Interface,** used to communicate with the COSMOS-TCMS system.

- **Non-volatile Memory**, for storing the events and their associated records, as well as data of interest.

- **Data Port,** for downloading the events record files for train maintenance functions.

4. SCREENS MANAGEMENT

Several different screens are foreseen to be displayed, which will be described in the following section.

- **Driving:** shown in light blue, with the most common controls and indicators that permit driving the streetcar.
- **Maintenance:** orange screens, which permit carrying out typical workshop parameterization, setting and check operations.
- **Programming**: red-colored screens, which permit modifying vital parameters for the functionality of the streetcar.

The screens are also organized in circles that define the allowed transitions (by pushbuttons that will appear on the lower part of the screen).

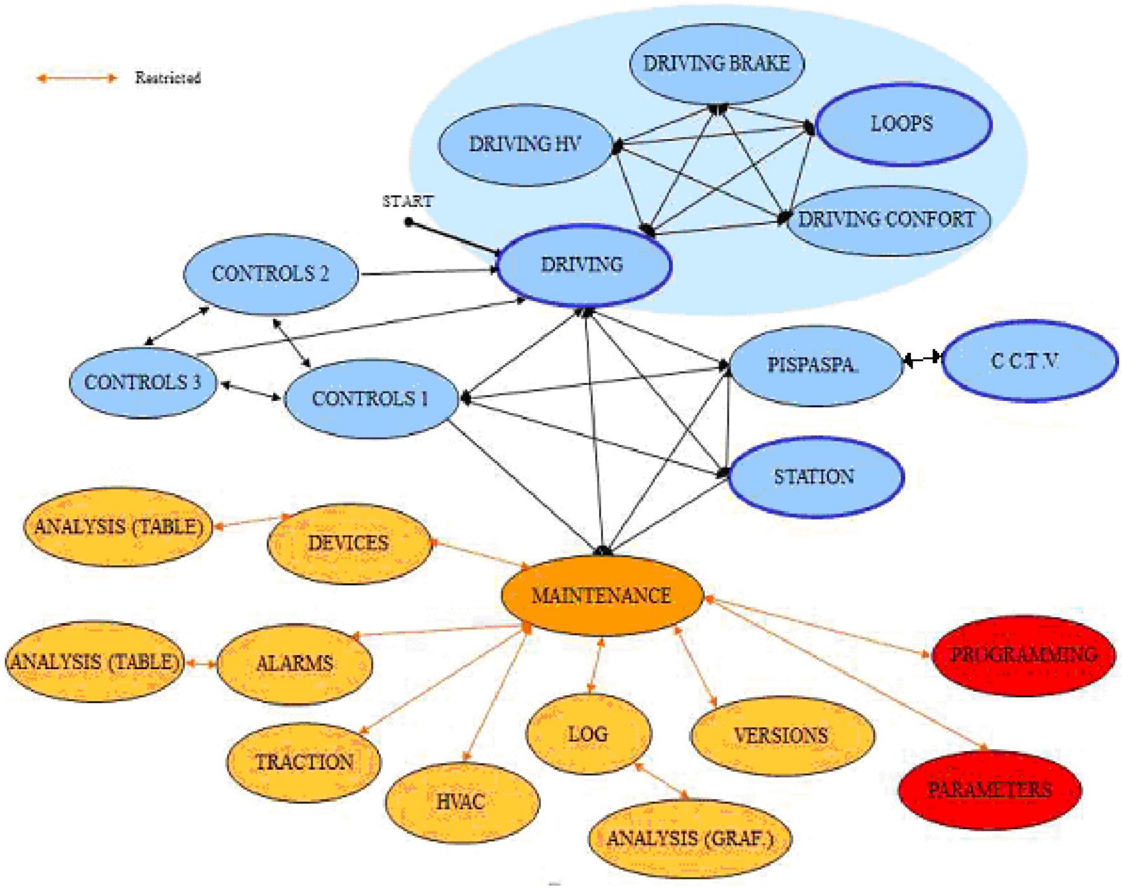


Figure 1 Screen management

According to this classification, navigation between screens can be:

- **Restricted**: when the HMI does not permit the change, if a certain password is not entered.
- **Unrestricted**: in the opposite case.

Restricted changes require user identification to change the screen. The access levels permitted are:

- **Driving**: it does not require any password; the unit just has to be started. The identification is carried out through means outside the HMI.
- **Maintenance**: a valid maintenance password is required to access the maintenance screens (TRACTION, HVAC, ALARMS, LOG and DEVICES screens).
- **Programming**: whose password permits access to all screens, including PARAMETERS and PROGRAMMING screens

Before entering to the screen with a high profile (maintenance or programmer users), a user authentication will be required. The password required will consist of a 4 digits code.

If a valid password is entered, it does not have to be entered again until a blue screen is accessed.

As a safety measure, the system blocks the restricted access for 10 minutes, if more than 3 consecutive failed attempts are received.

During the driving and for certain events the CCU of the TCMS system

forces the HMI to carry out an automatic transition to a more appropriate screen for the event context. The screens with automatic transition are shown in Figure 1 with a thick blue line:

- **Driving**: if the speed is greater than 3km/h, the system will automatically change to the DRIVING screen. This change will be inhibited if the system is on the DRIVING LOOP screen when a traction or speed loop has been opened.
- **Loops**: It will be activated by the CCU if one loop is opened when there is speed or traction. All automatically change will be inhibited after this, the user will can leave this screen only manually.
- **CCTV (PISPASPA)**: The system will automatically change if it detects the activation of any intercom.
- **Station:** Active when streetcar is stopped and doors enabled.

5. SCREENS DESCRIPTION

The screen description included within this document will be divided into the following points:

- **Objective and functionality**: where the objectives and uses of the screen in question will be explained.
- **Description**: where the different parts of the screen, the information offered by each one of them and the uses that can be made of them, are described.
- **Possible actions**: which includes the different actions that user can carry out on each screen and the reaction of the system to each one of them. “Navigation” between the screens can be considered in this section, as the screen changes permitted by the software are described.

With respect to the description of the screens, they all have a series of common elements that permit the rapid identification of general information. These common parts are described below to avoid repeating them in each section.

5.1 LABELS AND COLOURS

The colours of the icons will follow the next policy all over the screens:

- Black (OK): system or device activated and ok.
- Red (ALARM): system or device activated but not ok.
- Blue (WARNING): system bypassed, in standby mode or in a degraded mode.

Exceptions to this policy will come properly indicated.

5.2 COMMON ELEMENTS

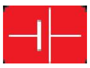
- **<u>Label bar:</u>** At the top of screen there is a horizontal bar which contains fields with the following general information:

Figure 2 Label bar

  - **Unit Number (TU)**: there is a reserved area in the screen for this information if available.
  - **Driving mode (MODE):** there is a reserved area in the screen for this information. Possible driving modes are F (Forward), W (Wash mode), R (Reverse) and N (inverter in neutral position).
  - **Date:** in month (number) - day and year (with four digits) **MM/DD/YYYY.**
  - **Time**: both the date and the time will have red background whenever the train time is not correct.

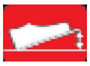
- **<u>Icon bar</u>:** Below, a second horizontal bar at the top includes a series of icons that sum up the status of the main train devices at any given time.

Figure 3 Icon bar

PANTOGRAPH	
	Pantograph down or Pantograph in failure
-	Pantograph raised
HSCB	
	HSCB open in the unit (OFF) or HSCB in failure
-	HSCB closed in the unit (ON).
TRACTION SYSTEM	
-	All traction converters are on and ready to traction
	No traction converter is ready to traction.
AUXILIARY CONVERTERS	
-	All auxiliary converters ON and not in failure (generating AC).
	All auxiliary converters ON but in failure (not generating AC).
BATTERY CHARGER	
-	All battery chargers are ON and generating DC.
	All battery chargers are ON but no generating DC.
SHVAC	
-	All the air conditioning systems of the composition ON with no failure.
	All air condition systems ON and in failure.

FRICTION BRAKES	
-	All brake devices of the composition are operative.
	One brake system of the composition is in failure.
	At least one brake system has been isolated.
PARKING BRAKE	
-	Parking brake not applied.
	Parking brake applied.
DOORS LOOP	
-	Doors loop closed.
	Doors loop open.
	Doors loop bypassed.
TRACTION LOOP	
-	Traction loop closed. Traction allowed.
	Traction loop open. Traction NOT allowed.
	Traction loop bypassed.

BRAKE LOOP	
-	All brake loops closed.
	At least one brake loop open.
	Brake loop bypassed.

DRIVER'S SAFETY DEVICE (DSD)	
	DSD working properly
	DSD in failure
	DSD bypassed

If there is no Icon showed, Streetcar is in “ready to go” state.

- **<u>Navigation bar:</u>** A third horizontal bar can be identified at the lower area of the display. It contains virtual pushbuttons to access to the different screens. They let user navigate between the different HMI screens.

  This bar is contextual, varying the function of the pushbuttons dynamically, which makes the system extremely flexible. The button highlighted in green identifies the current screen name.

Figure 4 Navigation bar

5.3 PERFORMANCE WITH ACTIVE CAB

The screen is normally ON in the active cab. However, under certain circumstances and in order to avoid distracting the driver, the HMI will be able to change the screen to black (TFT is turned OFF) although it can always be recuperated if the driver wants to, just by pressing on it (the touch function is always active).

Specifically, the HMI goes to black whenever v > 3km/h (no null speed).

Conditions of the immediate activation of the HMI screen are:

- Driver touches the screen. The screen will be OFF again after a predefined time of one minute without activity from last touch.
- Null speed detected (v < 3km/h).
- An event appears according to the defined severity in [Ref. 2]. The screen will be OFF again when all the events are acknowledged.

Generally, commands entered from HMI will only take effect if they are commanded within active cab.

5.4 PERFORMANCE IN NON ACTIVE CAB

When the streetcar has no active cab or it is in a process of cab changing, **the screen will remain ON.** The HMI will allow navigating through all the screens as well as viewing them, but it will not permit modifying or entering parameters into the screens.

Whenever exists in the composition an active cab, the non-active cab display will be OFF and won’t go to ON until that cabin turns into an active cabin or if it is touched. In this case, the non-active cab display will turn OFF if it is not touched again in next minute.

The non-active cabin HMI will continue processing information the same as the one in the active cabin (receiving and recording events) but **will not recognize commands entered** until its cabin turns to active one.

The HMI devices are independent and autonomous from each other, so that the navigation in a cab will not affect the other HMIs of the composition. Navigation with the HMI on a non-active cab won’t affect the HMI on the active cabin. For the active cabin HMI it will be as if no one were browsing in the non-active cabins.

5.5 STREETCAR SYNOPTIC

This document will use the following terms:

- Vehicle: equivalent to a streetcar unit which is composed by cars
- Car: equivalent to the modules of the streetcar

The HMI will show the streetcars of three cars (C1-S1-C2) with the active cabin shown in blue.

6. SCREENS CONFIGURATION

6.1 "TCMS BYPASS" SCREEN

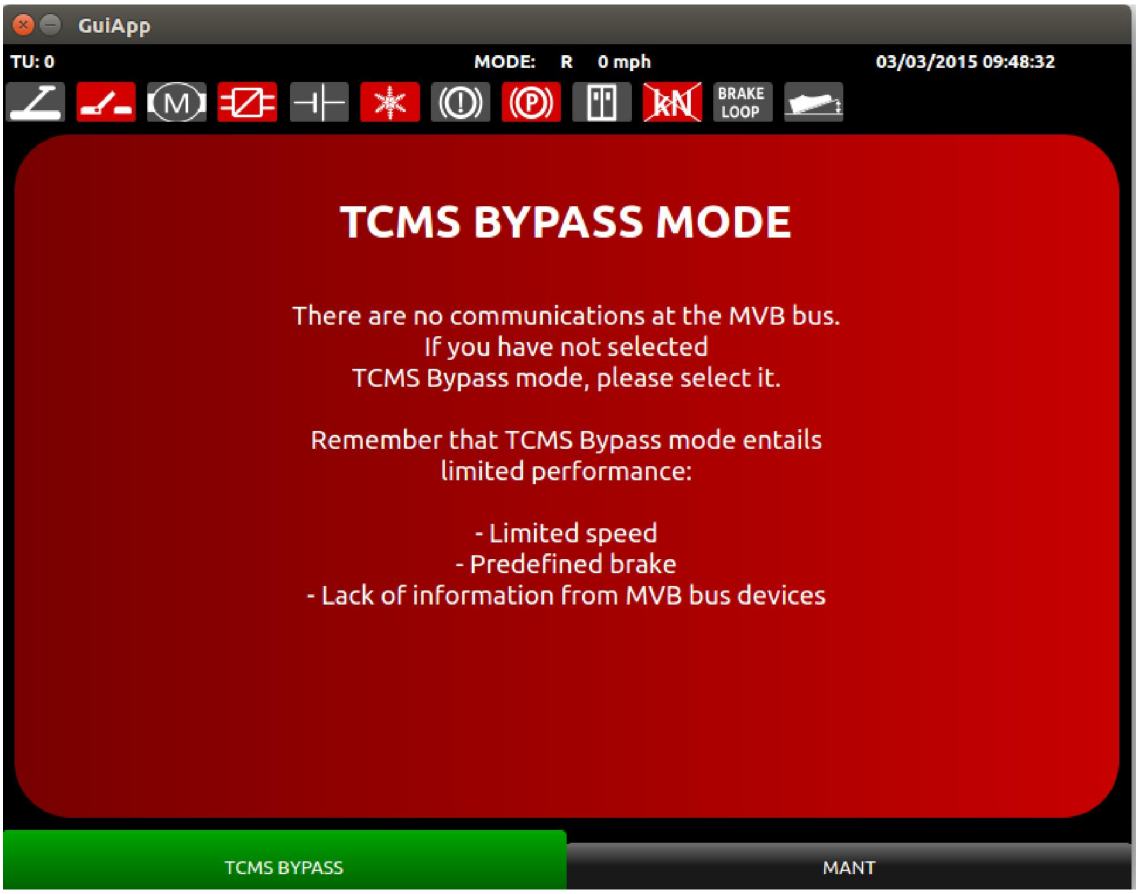


Figure 6 TCMS Bypass screen

The aim of this screen is to inform users about the status of total lack of communications in the bus, either due to general failure of the COSMOS-TCMS system or due to the activation of the TCMS BYPASS mode.

If a total lack of communications occurs (more than 90% of ports fail), the system shows a red box which contains the text shown in Figure 6. In this condition information is not reliable.

This TCMS BYPASS mode screen is shown automatically (whenever the fault status arises or TCMS degraded mode is activated) from the driving screens.

6.2 SCREENS TO BE USED BY THE DRIVER – DRIVING SCREENS

The driver has accesses to the following screens

- DRIVING SCREEN
- CONTROL SCREEN

- STATION SCREEN
- PIS SCREEN (Passenger Information System Screen)

6.3 SCREENS TO BE USED BY THE MAINTENANCES STAFF – MAINTENAINCE SCREENS

The maintenance staff has accesses to the following screens

- DEVICES SCREEN
- TRACTION MAINTENANCE SCREEN
- HVAC MAINTENANCE SCREEN
- CONTROLS SCREEN
- ALARMS SCREEN

6.4 SCREENS TO BE USED BY THE HIGH PROFILE USERS (MAINTENANCE OR PROGRAMMERS)– PROGRAMMER SCREENS

The screens aimed to the programmers are the following ones:

- LOG SCREEN
- VERSIONS SCREEN
- PROGRAMMING SCREEN
- PARAMETERS SCREEN

7. DRIVING SCREENS

7.1 “MAIN” DRIVING SCREEN

Pressing “DRIVING” pushbutton over the *“Navigation bar”*, the main driving screen will be shown and the complementary driving screen pushbuttons will be appear al the right of the bar to be accessed by the driver:

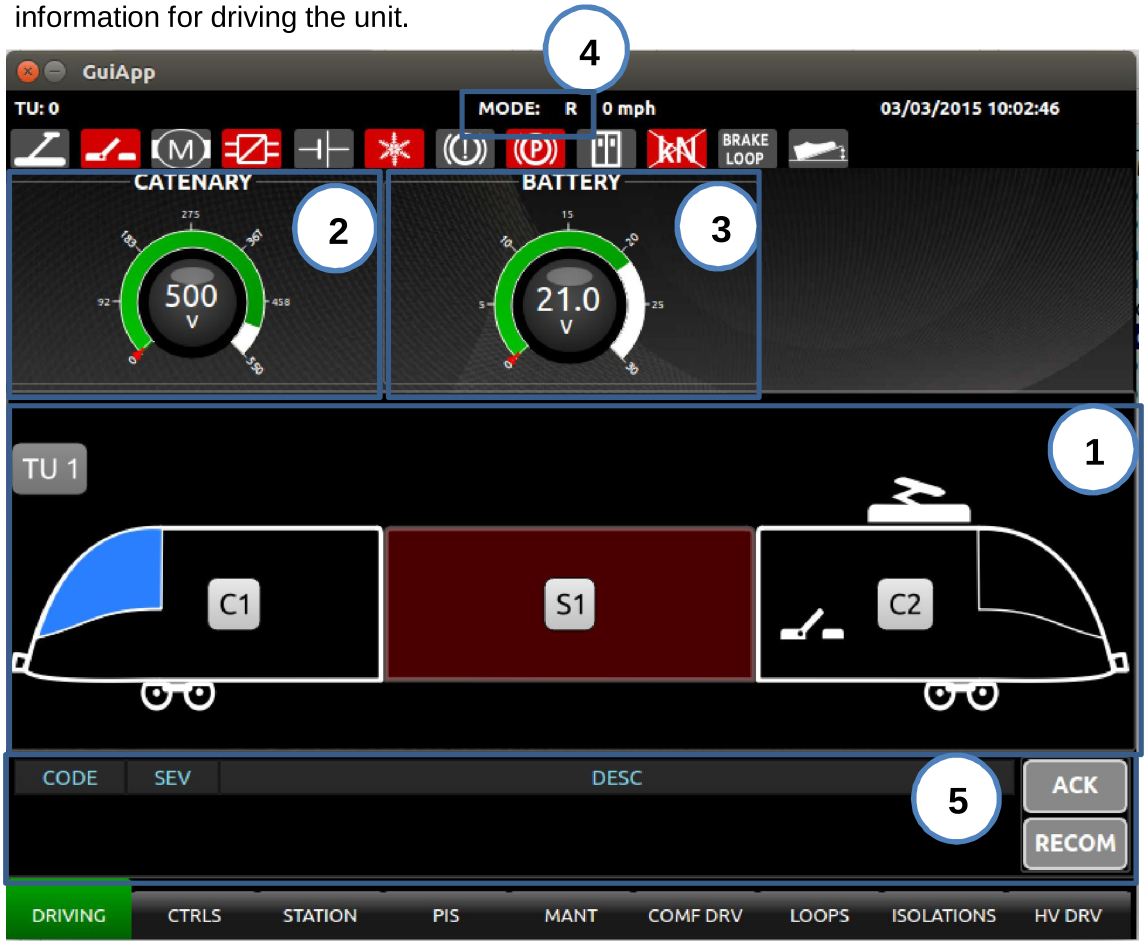
- Comfort Driving screen (COMF DRV)
- Loops screen (LOOPS)
- Isolations screen (ISOLATIONS)
- HV Driving screen (HV DRV)

Figure 7 Driving screens

The 'main' driving screen must be the screen to be displayed on the HMI in **normal driving during the service.**

The function of this screen is to facilitate the driving operation, giving information that might be useful at any time.

Thus it shows the information about the main equipment and other useful information for driving the unit.



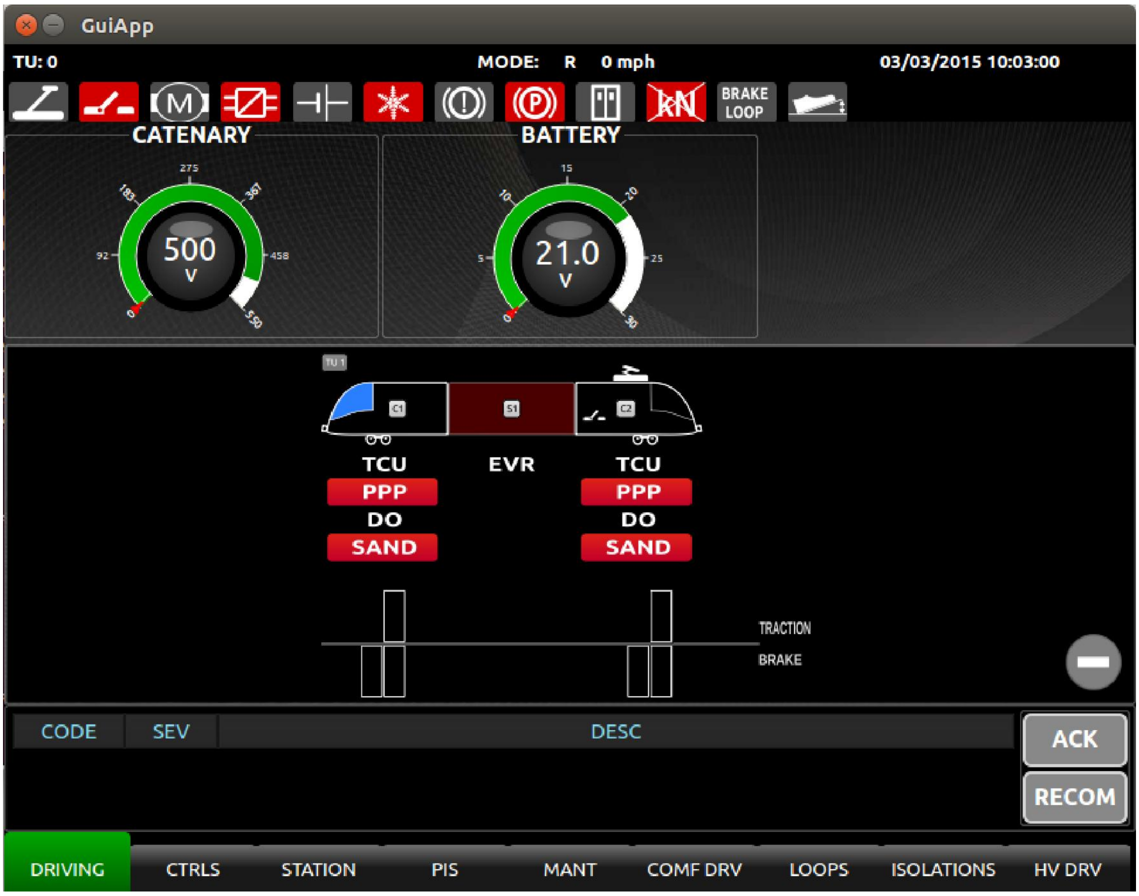


Figure 8 'Main' Driving screen

This screen shows the following information:

1) **Streetcar synoptic**: a synoptic of the composition appears in the centre, in agreement with the operation order, showing the enabled cab with green background. The cars are identified in absolute terms: C1 – S1 – C2.

In the composition synoptic, the following drawings can be seen:

a) **Pantograph**: synoptic of a raised pantograph in car C2**.** This icon indicates when the pantograph is raised.

b) **HSCB**: synoptic of an HSCB inside the car C2. This icon has two statuses present (closed and open) that are mutually exclusive and is therefore always.

c) **Traction/Brake total effort**: an analogical indicator appears under each car truck, which shows the total effort, both in traction and in brake (distinguishing between friction FR brake and electric ED brake), that each car truck is making.

d) **Main equipment**: besides, in the driving screen in UT view mode, below each car there are boxes/labels which are representative of the status of each main device of that car.

Main equipment labels will have a black background, indicating that the equipment is operative (ON and OK).

They will have a red background, indicating that the equipment in question is not operative. This status may be due to a general failure of the system in question or to the lack of a necessary condition for it to work (for example, absence of high voltage).

And finally some labels can have a blue background, indicating equipment bypassed, in a degraded mode or in a standby mode.

2) Catenary: the current catenary voltage is shown with an analogical/digital indicator. Below 525 volts the analogical indicator must be represented in red. Above configured voltage (525 volts) it will be presented in green.

3) Battery: another analogical/digital indicator shows the battery voltage of the streetcar (0-30v). Below 22 volts the analogical indicator must be represented in red. Above configured voltage (22 volts) it will be presented in green.

4) Driving mode: it shows the selected driving mode

F: Forward.

W: Forward at 03km/h (*Wash mode*).

N: Neutral position (no driving mode has been selected).

R: Reverse.

5) Alarms/Events list: Major or minor faults, incidences and/or advertisements to be displayed to the driver while driving will be set and shown at the bottom of the driving screen until they are acknowledged.

An event will have the following fields:

- Severity/Category. (SEV)
- Event code (60 chars. maximum) (CODE)
- Text describing the event. (DESC)
- Recommendation to the driver (90 chars. maximum). (RECOMMENDATION)

7.1.1 'Comfort' DRIVING SCREEN (COMF DRV)

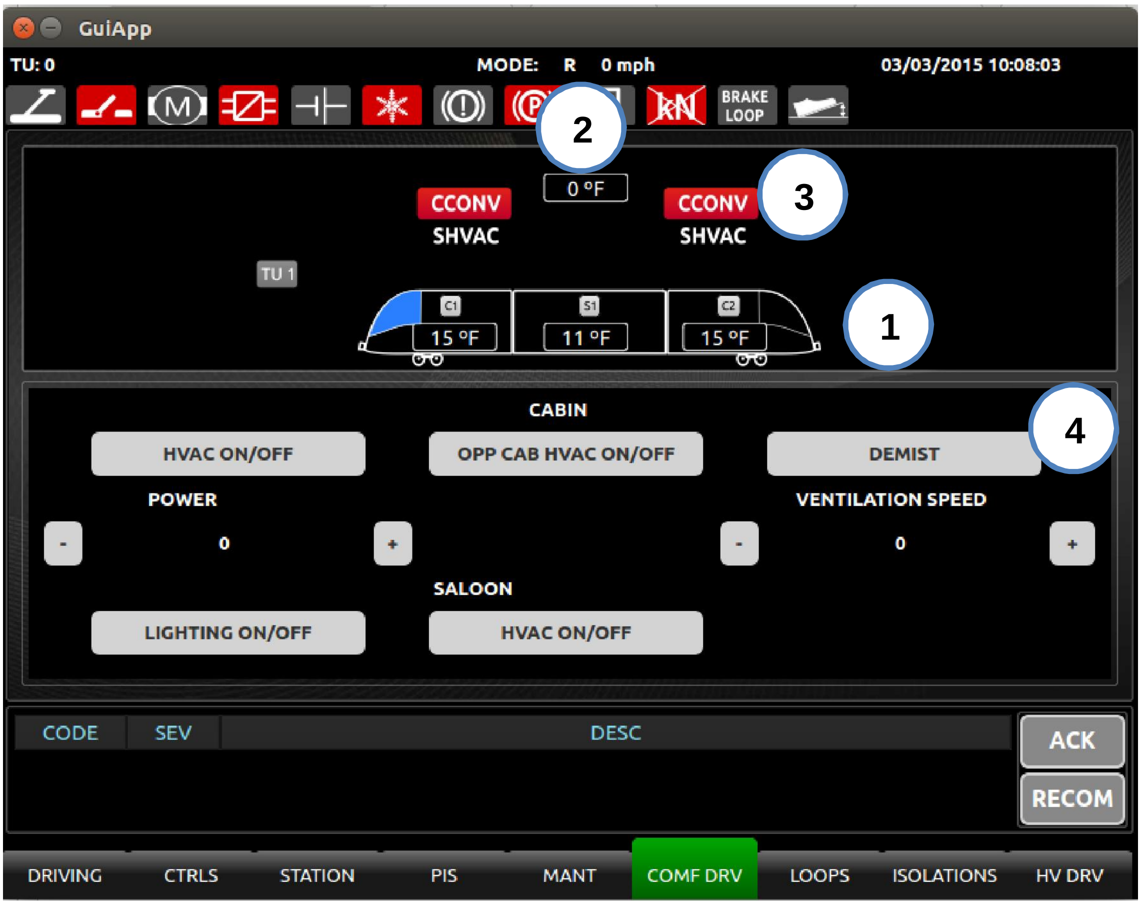


Figure 9 Comfort Driving screen

This screen permits controlling and knowing the status of the comfort elements in cab and passenger compartment.

The synoptic of the streetcar shows:

1) Temperature inside the vehicle

2) Temperature outside

3) Status of the system:

- ON if black color
- In failure or not communicating if red color

4) The screen has several buttons and indicators which let the driver control the comfort systems of the train.

- **Cab convectors Level**: It permits increase/decrease the heating power demand from 0 (power off) to 4 as well as ventilation speed from 0 (fan off) to 2.

If level power 4 is selected, highest speed of fan is automatically forced.

- **Passenger compartment HVAC (damper)**: it permits switch ON/OFF the passenger compartment HVAC.
- **Passengers lighting**: it allows the driver to switch ON/OFF the part of the passengers lighting which it's not defined as emergency lighting. The emergency lighting covers approximately the 30% of the passenger compartment lighting and it will switch on automatically when the streetcar is on.

7.1.2 'Loops' DRIVING SCREEN

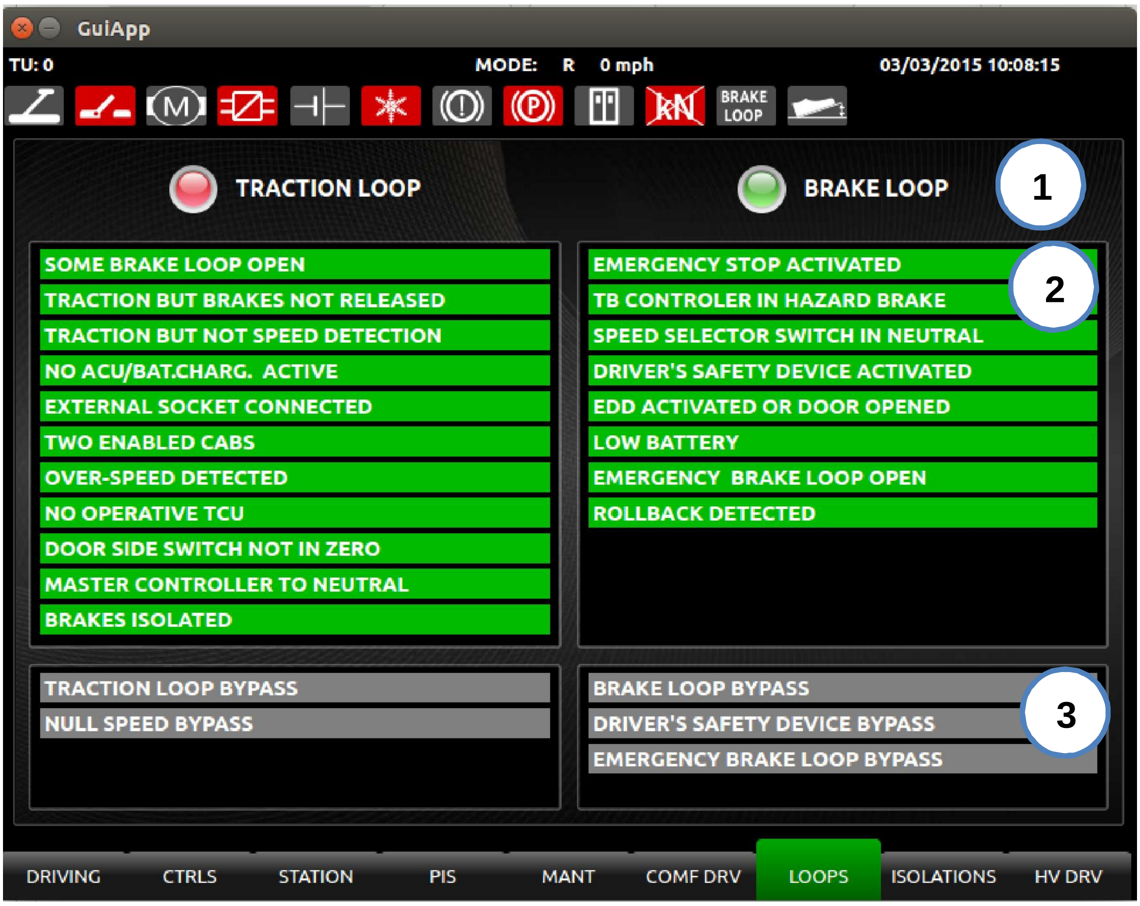


Figure 10 Loops Driving screen

The main aim of this screen is to know the status (and the cause of this status) of the main streetcar loops. These main loops are the traction loop and brake loop.

With the term brake loop, all the streetcar brake loops are included (Emergency 1&2 brake loop, Emergency 3 and emergency 4/safety brake loop).

1) The status of each one of the main loops is represented with an indicator which can have two possible statuses:

- **Green**: indicating that this loop is closed
- **Red**: indicating that this loop is open

Both the possible causes that open or close the loop and the possible bypasses that are skipped by some conditions of each loop are shown too.

2) The opening loop causes are shown with two possible statuses:

- **Red** if the cause is **opening the loop**
- **Green** if the cause is **not opening the loop**

3) The loops bypasses:

- **Blue,** indicating that the loop bypass **is activated.**
- **Black**, indicating that loop bypass **is not activated.**

7.1.3 'Isolation' DRIVING SCREEN

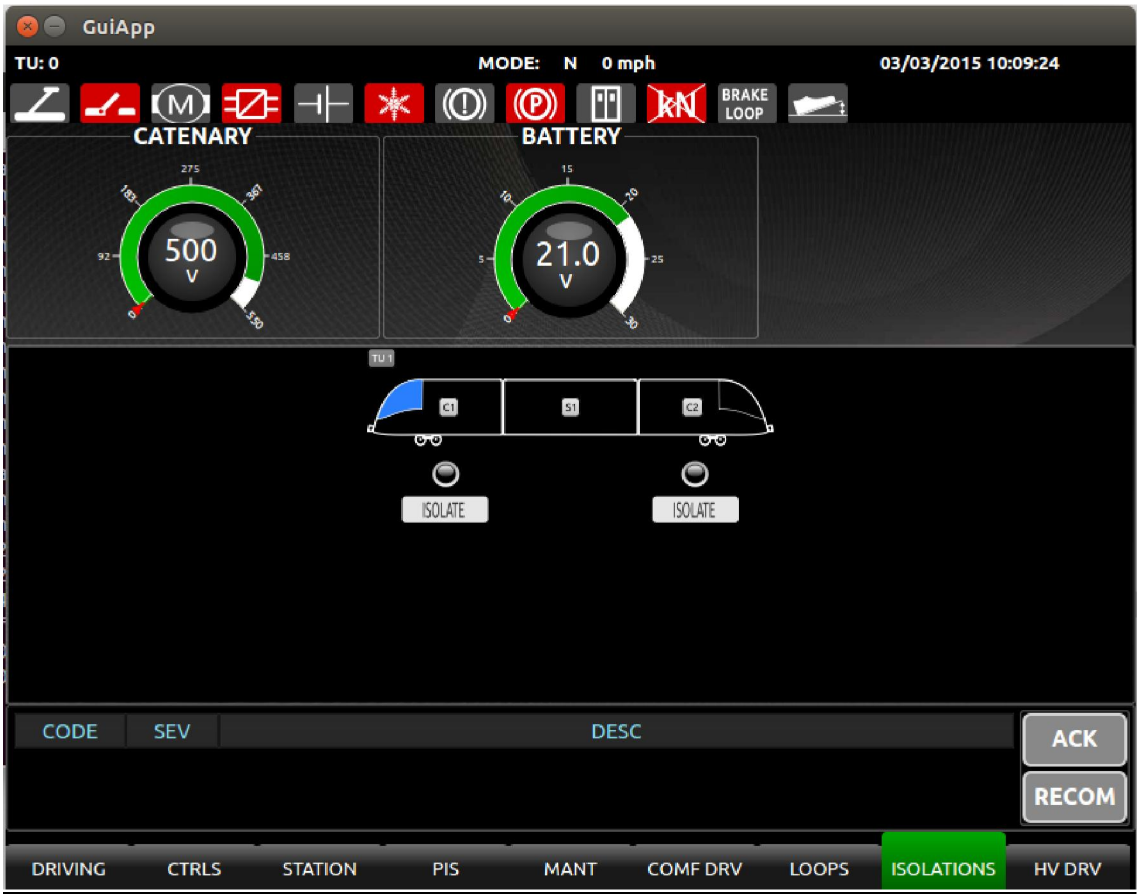


Figure 11 Isolation Driving screen

The aim of this screen is to control the status of the brake devices throughout the unit.

<u>*ATTENTION*</u>*:* **Driver can disable through this screen only one brake in fail**.

When the equipment has given a negative value in the auto-test (system is not ok) and the train control system considers it appropriate (no other truck is isolated), the driver may isolate the brake device by pressing the corresponding ISOLATE pushbutton.

Under each car truck there is a pushbutton with its associated indicator to isolate the faulty hydraulic brake.

- If no brake is isolated, indicators will be shown in black
- If brakes are isolated, indicators will be shown in blue

If pushbuttons below indicators are pressed:

- ISOLATE, the brake will be isolated (and the indicator will turn to blue)
- ENABLE, the isolated brake will be cancelled (and the indicator will turn to black)

7.1.4 'High Voltage' DRIVING SCREEN (HV DRV)

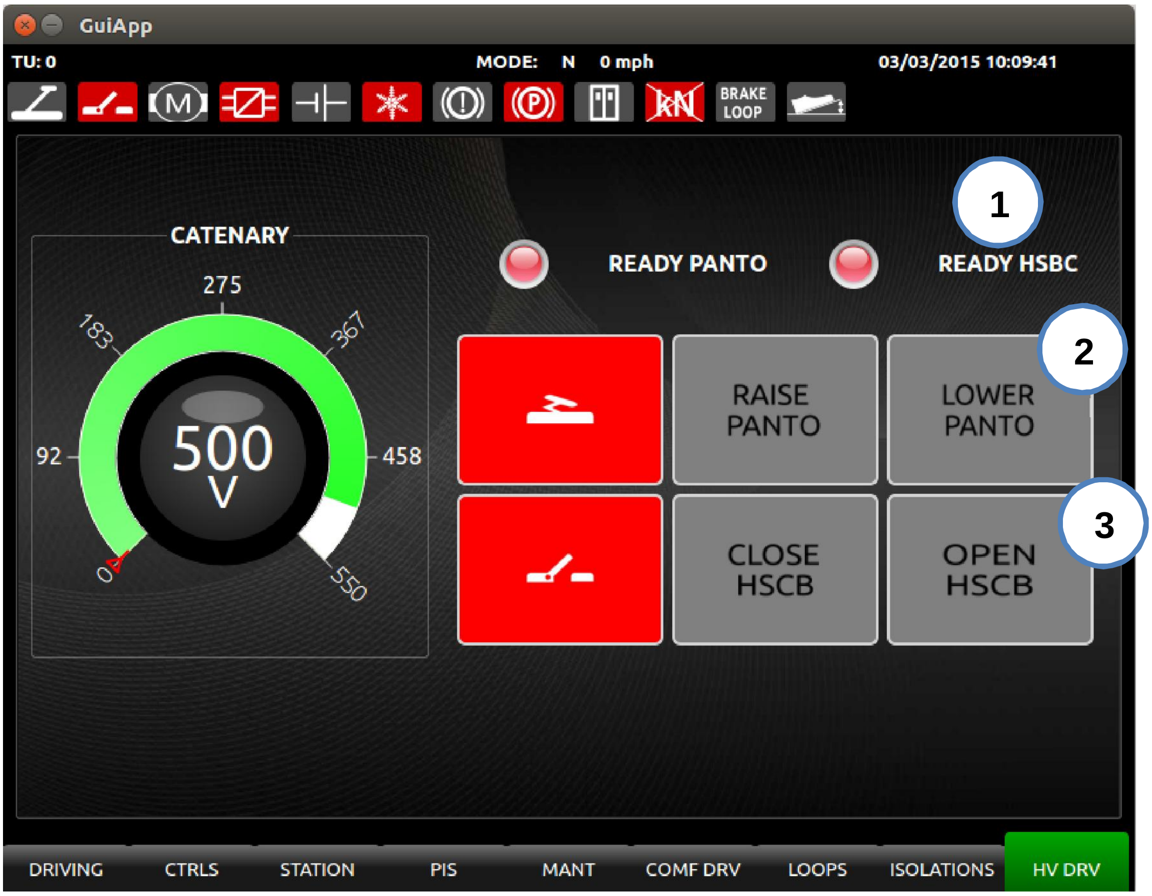


Figure 12 High Voltage Driving screen

The main aim of this screen is to know and control the status of the high voltage elements of the train, the Pantograph and the HSCB.

1) Status of the HV elements:

- **Pantograph Down and HSCB Open,** label background in red
- **Pantograph Up and HSCB Closed**, label background in black

2) Actions:

The pushbuttons of this sub-screen permit the following actions on the high voltage elements:

- **Raise Pantograph:** to request raising the pantograph if is down
- **Lower Pantograph:** to request lowering pantograph if it is up.
- **Open HSCB:** to request opening the HSCB if it is closed.
- **Close HSCB:** to request closing the HSCB if it is opened.

3) "**Ready" indicators,** which turn to green when the streetcar is ready to raise the pantograph (***READY PANTO*** indicator) and to close the HSCB (***READY HSBC indicator***). These conditions are necessary to enable the pushbuttons. If the streetcar is not ready to raise the pantograph and to close the HSCB, indicators will be shown in red.

7.2 "CAB CONTROLS" SCREEN (CONTROLS)

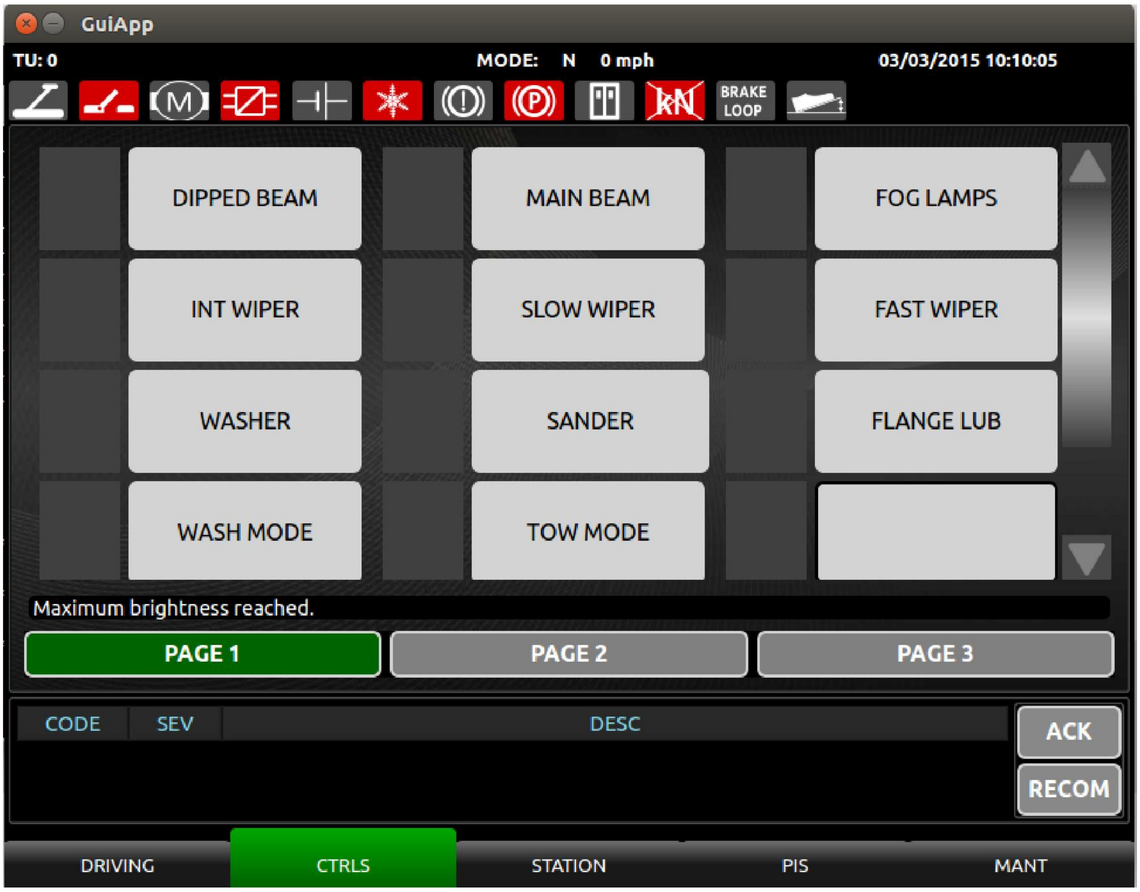


Figure 13 Cab Controls screen

The main aim of this screen is to permit the execution of the vehicle controls, and offer a redundancy of the physically controls in the cab driver's desk. This means that if a fault situation occurs in a pushbutton on the desk, the same order can be executed from the HMI 'virtual' pushbuttons.

Likewise, it increases the number of available controls for functions of infrequent use that do not require a physical pushbutton on the desk.

Pilots will be shown in green if action is activated or in black if action is not activated.

The 'virtual' controls to include within these screens will be the following:

CONTROLS PAGE 1		
DIPPED BEAM	MAIN BEAM	FOG LAMPS
INT WIPER	SLOW WIPER	FAST WIPER
WASHER	SANDER	FLANGE LUB
WASH MODE	TOW MODE	

CONTROLS PAGE 2		
	BOOST	LOW BATTERY BYPASS
LAMP TEST	HV CONNECT	TRAM DISCONNECT
HMI BRIGHT +	HMI BRIGHT -	FIRE MODE
WINDSHIELD HEATING		BELL

CONTROLS PAGE 3		

7.3 "STATION" SCREEN

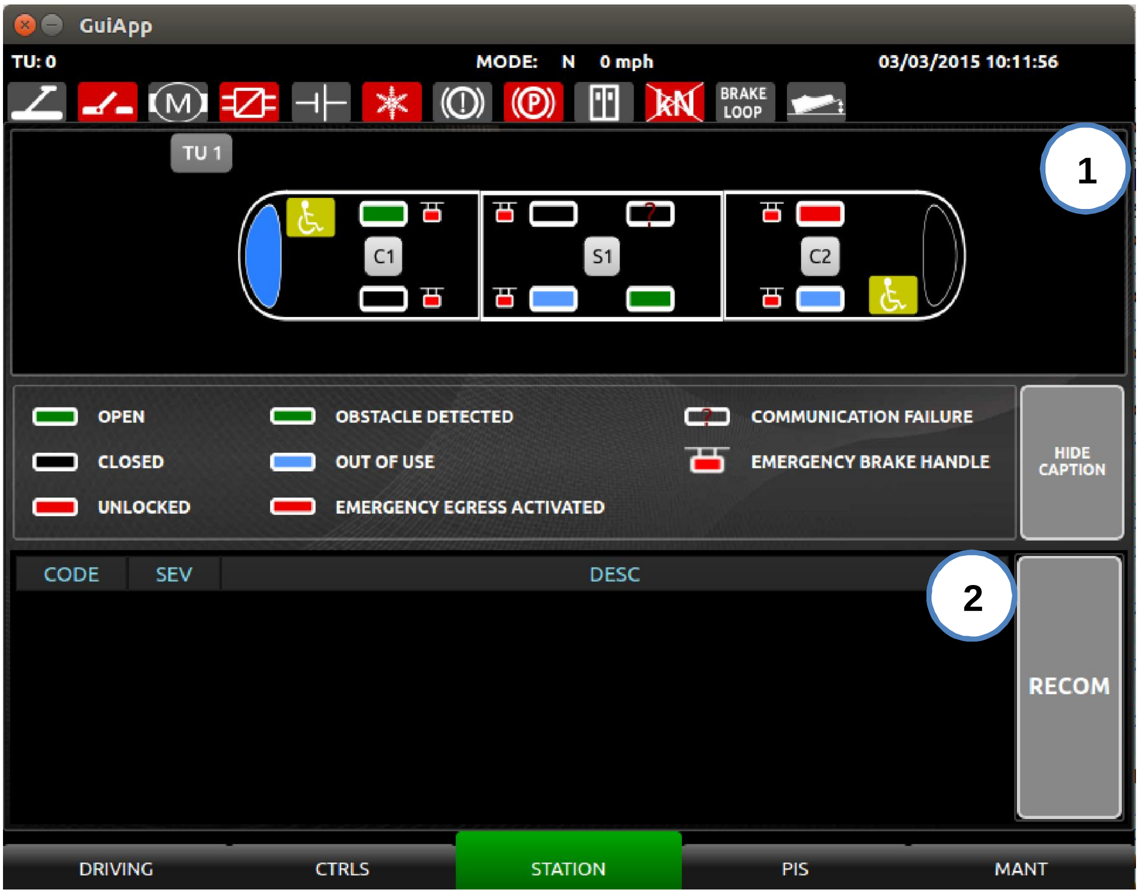


Figure 14 Station screen

Automatically and under certain conditions described below, the system changes to this screen to obtain relevant information when streetcar is in a station.

Changing to the STATION screen is automatic from the DRIVING screens and takes place under the following conditions:

- The train stops (there is null-speed, v<3km/h).

- The opening of any door side is enabled (side door enabled).

The aim of the STATION screen is to show and inform about the active anomalies as well as the information necessary at a station. This screen also offers information about the alarms and permits accessing to their location.

The screen has two parts:

1) A **synoptic of the vehicle** appears at the top

The composition is shown with the enabled cab in blue.

A green line along the unit indicates the enabled door side. Top green line in the streetcar synoptic means right side doors enabled (respect active cab

showed on the left) and a bottom green line means left side doors enabled.

The doors are represented with a rectangle on the synoptic, shown in their six possible statuses (classified from greater to lesser priority):

- **Door in communications failure:** box with “?” symbol means that there is a communication failure with that door
- **Door in failure**: in red due to a major failure of the door.
- **Locked out of use or isolated door**: blue. The door is closed and locked out of use, so the passengers cannot use it.
- **Emergency egress device activated**: red flashing. The door has been unlocked by normal operation. The emergency brake handle will be represented by means of a red triangle when activated (Δ) and hidden when not activated.
- **Obstacle detected when closing**: green flashing. The door is blocked by an obstacle and cannot get closed.
- **Door open**: green. The door is open. Normally it is due to stopping at a station.
- **Door closed**: black. Only the transparent rectangle is shown.
- **Stop request**: In this screen appears the MIA indicators ( ) which has a black background whenever a stop request button has not been pressed and turn to yellow when the respective stop request button has been pressed in the composition.

The pushbutton SHOW/HIDE CAPTION shows and hides the legend that explains the meaning of the synoptic icons.

2) The lower area of the screen where the alarms/events list is shown as table with three columns.

- Severity/Category. (SEV)
- Event code (60 chars. maximum) (CODE)
- Text describing the event. (DESC)

When the alarms/events no longer exist they will disappear from the screen; they are removed and the ones that are still active are re-classified.

This list of active events can be classified according to three criteria

- Severity/Category (most serious at the top and within each level of severity, the most recent alarm at the top).
- Code number (lowest to highest code number).

To change from one classification criteria to another one, the user must press the desired criteria on the column title (upper bar). The **default criteria** will be classification **by severity**.

The user can use the vertical arrows to select one of the activated events. Pressing the "RECOM" pushbutton (RECOMMENDATION) it will be shown a texts for the driver information. Pressing again the "RECOM" pushbutton, the recommendation text will be disappeared.

The default status of this box is hidden; it means that every time the screen is accessed the driver won't see the recommendation. "RECOM" pushbutton must be pressed to be seen.

When the speed increases to above 3-5km/h (no null-speed), the system will automatically change to DRIVING screen, to continue the operation.

The default status of this box is hidden; it means that every time the screen is accessed the driver won't see the recommendation. "RECOM" pushbutton must be pressed to be seen.

7.4 "PASSENGER INFORMATION SYSTEM" SCREENS (PIS)

The PIS system is controlled entirely by the HMI. From main screen, routes and announcements screen can be accesed..

7.4.1 PIS 'Main' SCREEN

Figure 17 Main PIS screen

This first screen is divided two areas. At the top there is a picture of the consist (in this case one streetcar) where all the intercommunication devices are represented.

Below the synoptic several information and commands can be found.

- Special message text in execution.
- Route number.
- Route not loaded message indication.
- Route destination.
- Speaker volume.
- Announcement exit side (right/left).
- Change station announcement side command before announcement.
- Current and next station
- Cancel next station command.
- PIS system data base load error.
- Load/Change route command.

7.4.2 'Route / Announcements' PIS SCREEN

Figure 18 Route/ Announcements PIS screen

This screen is divided in two areas:

- Route and stations: Here the driver will select the route in the “Route” column and in the “Station” column” the Stations within the route selected will be shown.
- Special messages: In the right side of the screen there will be listed all the special messages. The driver will be able to select one and launch it.

In both cases the driver has to select the option and tap the corresponding button to load the route or the message selected.

Once the selected option is loaded properly, the HMI will pass automatically to the Main Screen and it will show the information related to the selected option. If the loading is not done correctly, the HMI will show a pop-up message informing about the error and saying to try again.

8. MAINTENANCE SCREENS

The screens to be accessed by the maintenance staff are the following ones:

- Devices/Systems screen (DEVICES)
- Traction Maintenance screen (TRACT MAINT)
- HVAC Maintenance screen (HVAC MAINT)
- Controls screen (CRLS)
- Alarms screen (ALARMS)

Before entering to a screen with high profile (maintainer, programmer), a user authentication will be required. The required ID consists of a 4 digits code.

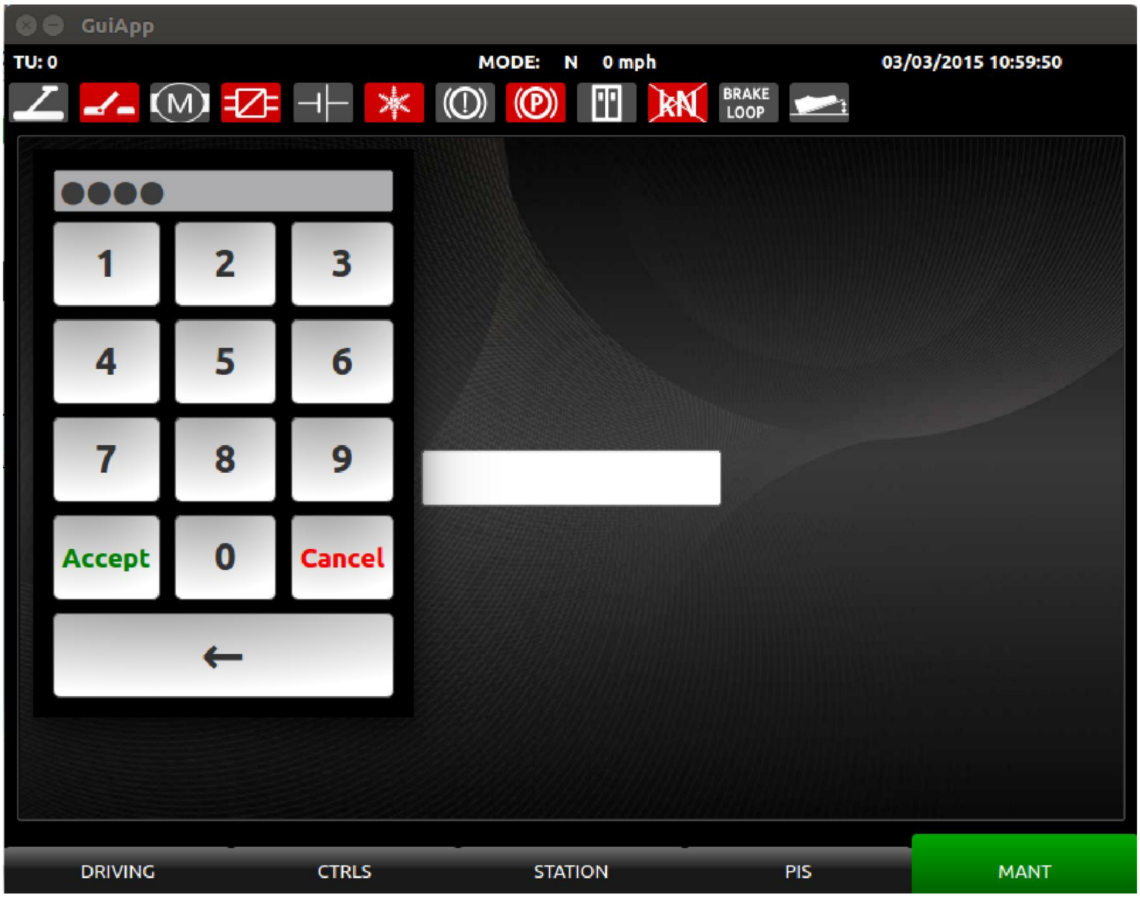


Figure 23 Control access keyboard

8.1 'DEVICES/SYSTEMS' SCREEN

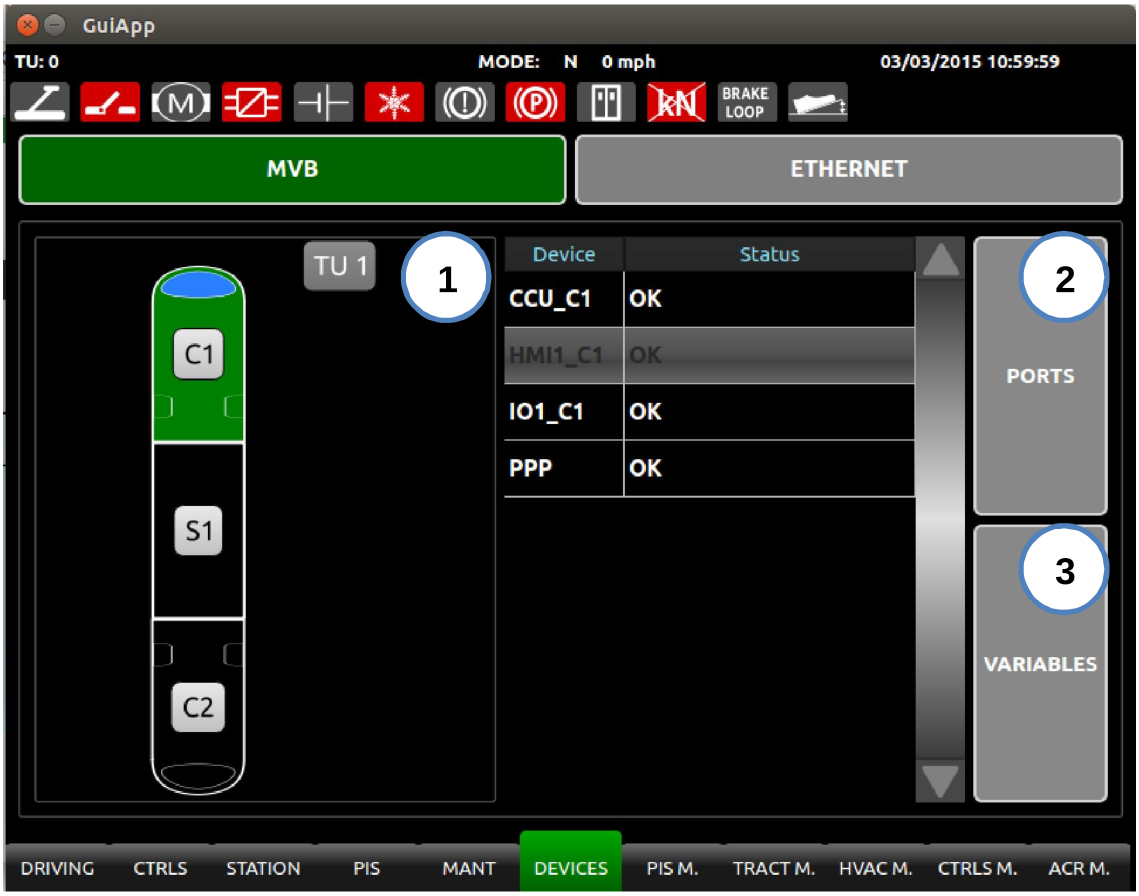


Figure 24 'Main' Devices screen

The purpose of this screen is to show information pertaining to the communications status of the most important devices or systems installed in the streetcar. It allows the user to select a specific device on each car and to view the most relevant information associated with it.

In order to do so, three screens are displayed:

1) 'Main' Devices Screen

The first screen allows, once one has been selected, showing the devices list of the car. Car is selected just pressing on it in the vehicle synoptic and then it turns to green.

The list contains the equipments or devices which can be selected, depending on the selected car. There's a possibility to scroll them in case of many devices.

2) 'PORTS' Screen

This screen allows real-time viewing of the communication ports of the selected equipment or devices. The user can select a device from list shown in the main screen and see the communication ports just pressing the virtual pushbutton "PORTS".

For each device, the name of the group of communication ports is defined by the Port ID (PortID), Logical address (Address), Size (in bits), Period (in ms), Status (Ok or NO Ok) and the number of errors (Errors)

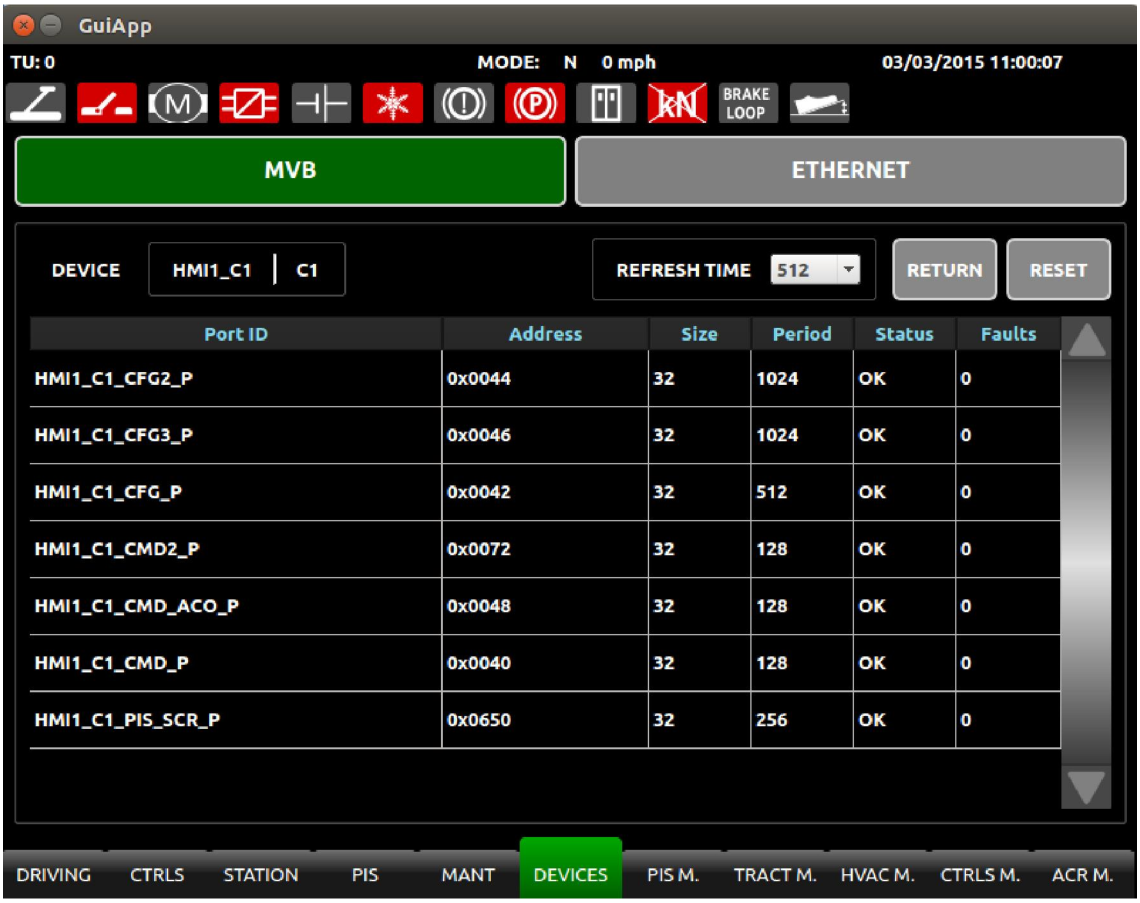


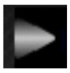
Figure 25 Ports screen

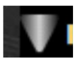
3) 'VARIABLES' Screen

This screen allows real-time viewing of a set of predefined variables for that equipment.

The user can select a device from list shown in the main screen and see the variables just pressing the virtual pushbutton "VARIABLES".

For each device, the name of the variables (VarName) defined in the configuration file and their current (in real time) values (Value) are shown.

Bitset type variables can be splitted by pressing  button so the value of each bit in real time cab be checked.

To merge the bitset,  pushbutton must be pressed

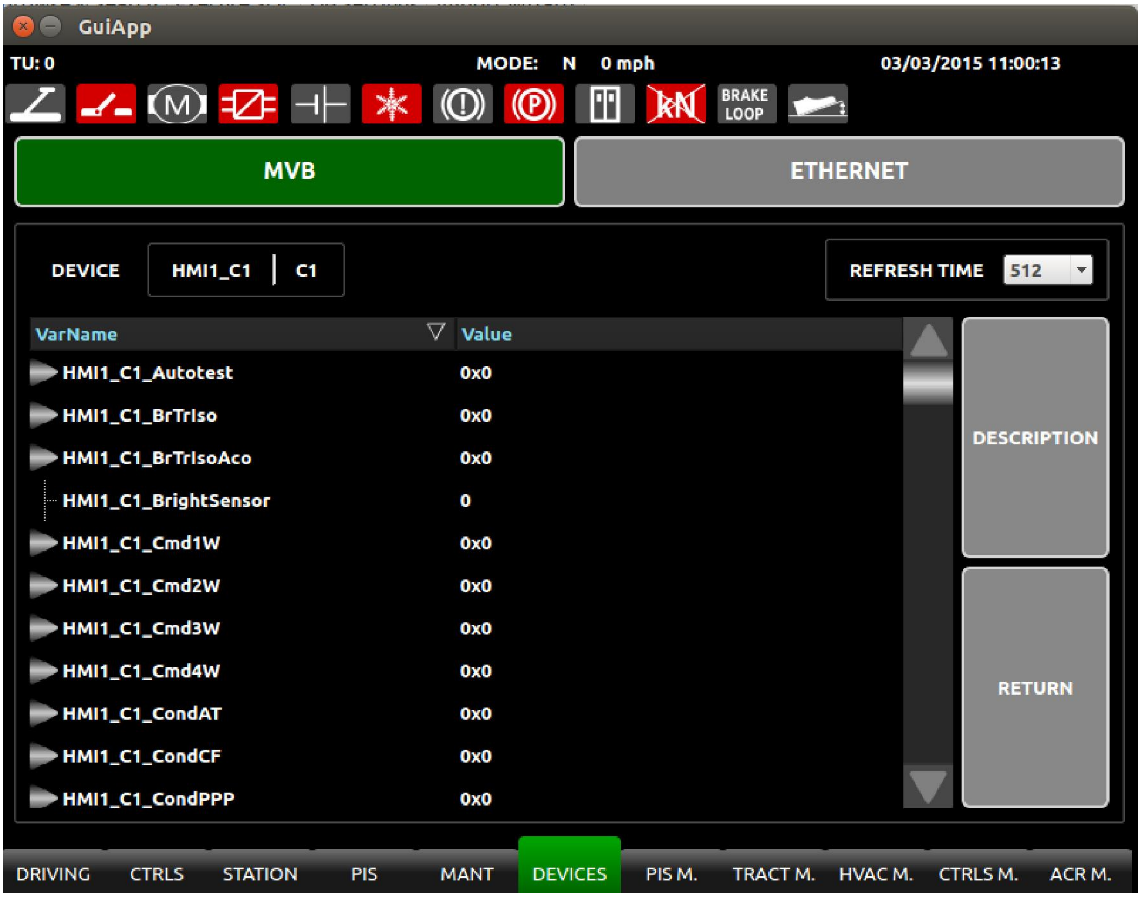


Figure 26 Variables screen

The upper left corner of the screen shows the name of the screen, the car and the name of the selected system/device.

Refresh Time variables can be increased/decreased by selecting the refresh time in the upper right checkbox.

The active operational buttons on this page are the following:

- DESCRIPTION: to show the comment associated to the selected variable.

- RETURN: for going back to the ‘main’ devices screen.

The user can also view several pages of variables of the same piece of equipment (if there are more pages) by pressing the horizontal arrows (forward and back in the pages), as indicated by the text at the top right part of the screen.

8.2 " TRACTION" MAINTENANCE SCREEN (TRACT MAINT)

This screen shows a diagram of the complete Traction system. Its purpose is to show graphically the main components, the main variables and parameters of the system, so the maintenance technicians will be able to know quickly its general status.

For further information, see technical description of Traction system.

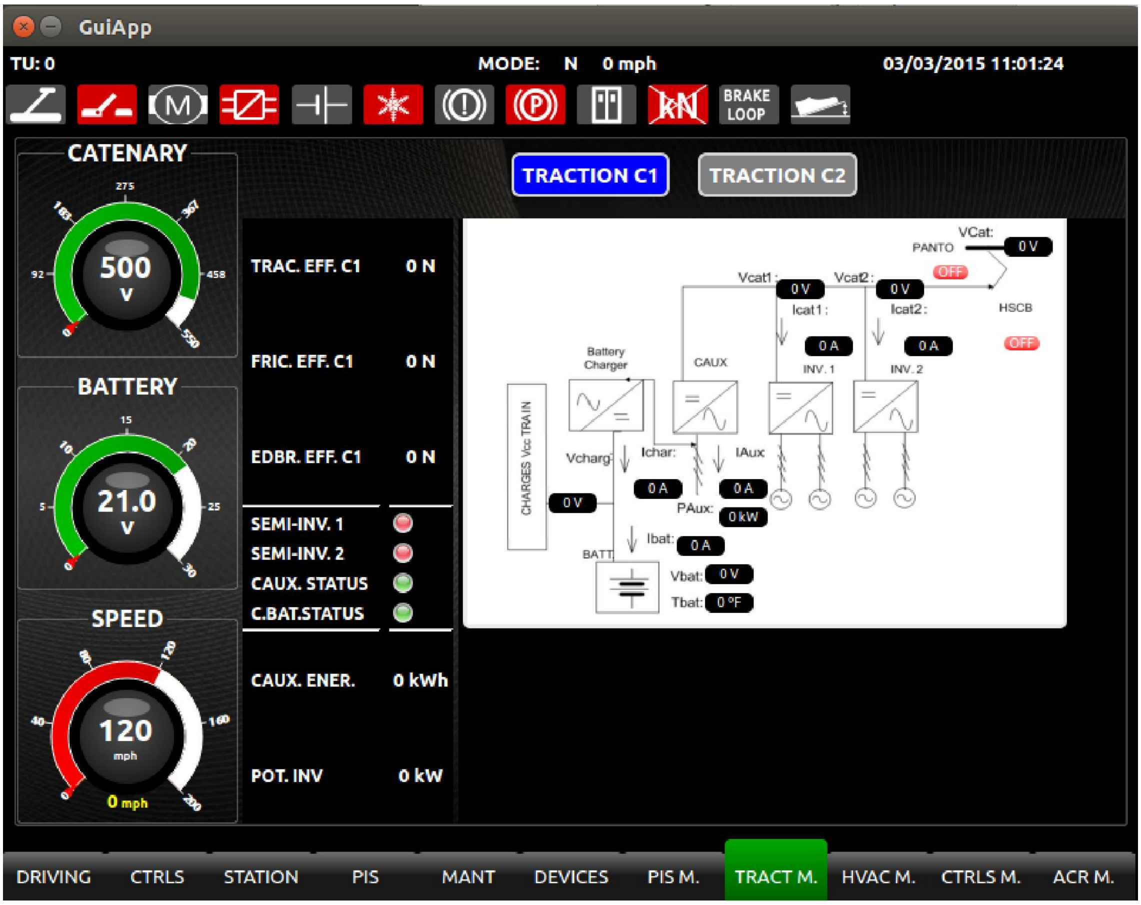


Figure 28 Traction Maintenance screen

8.3 "HVAC " MAINTENANCE SCREEN (HVAC MAINT)

This screen shows a diagram of the complete HVAC system. Its purpose is to show graphically the main components and the main variables and parameters of the system, so the maintenance technician will be able to know quickly the general status of the system.

HVAC pushbuttons let to select the HVAC system associated with the car where it is located.

These screens may start and switch off (to force) certain sub-systems of the HVAC selected.

For further information, see maintenance documentation of Passenger compartment HVAC system.

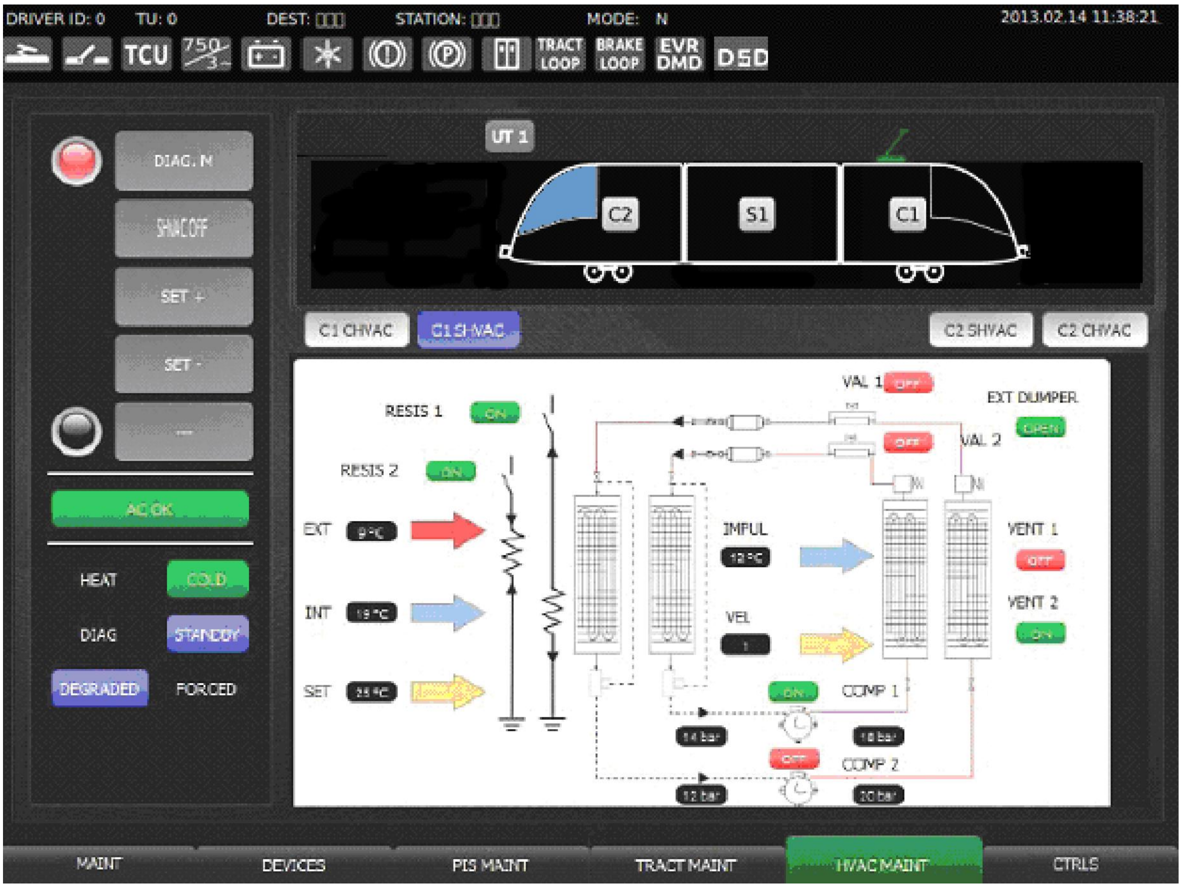


Figure 30 Passenger compartment HVAC Maintenance screen

8.4 "CONTROLS" MAINTENANCE SCREEN (CRLS)

The main aim of this screen is to permit the execution of the train commands reserved to maintainers.

Only Maintenance/Programmer staff identification will let the navigation to this screen with specific controls set for maintenance functions.

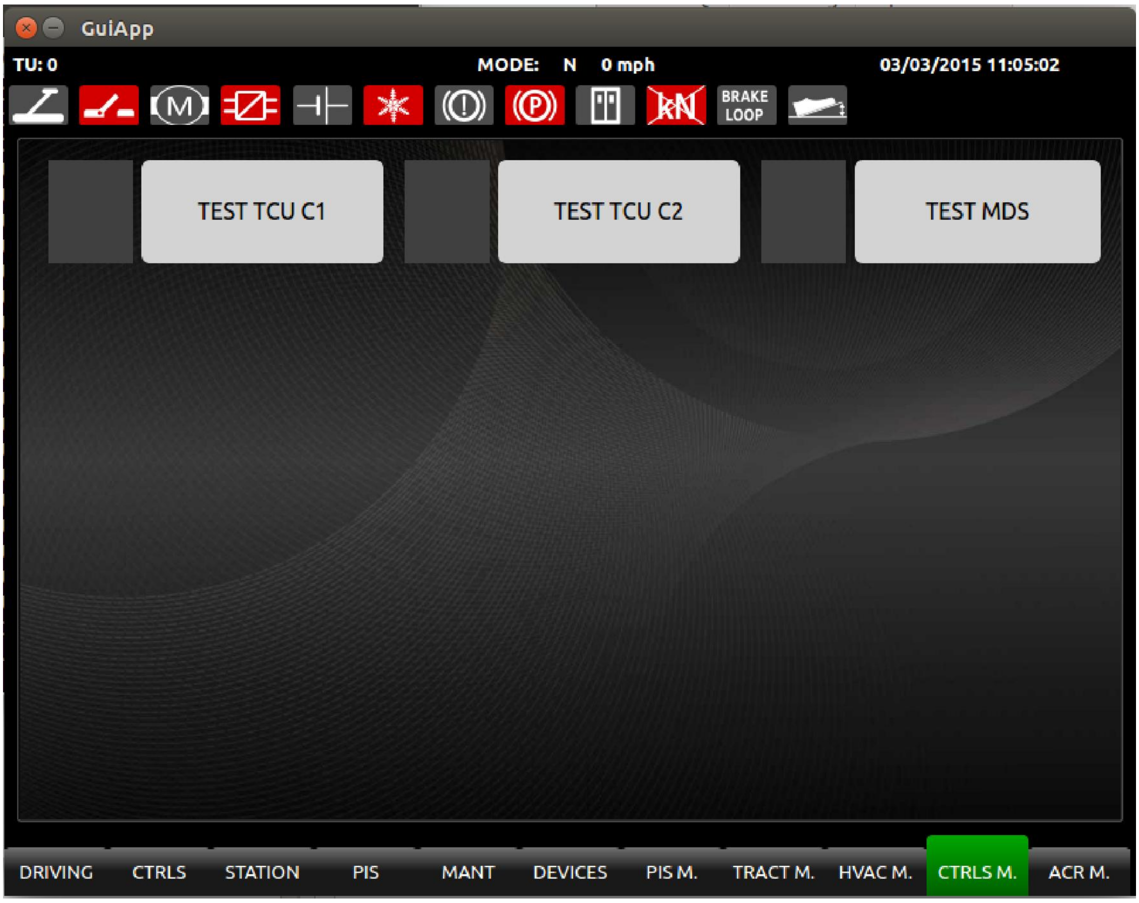


Figure 31 Controls Maintenance screen

8.5 "ALARMS" SCREEN (ALARMS)

The purpose of the ALARMS screen is to **show and report to maintenance** staff (or to the programmer) **all the active alarms at a given time**, as well as their severity.

Faults recorded are classified by the following severity/category according to ref. 2 Q.41.98.212 (Event specification).

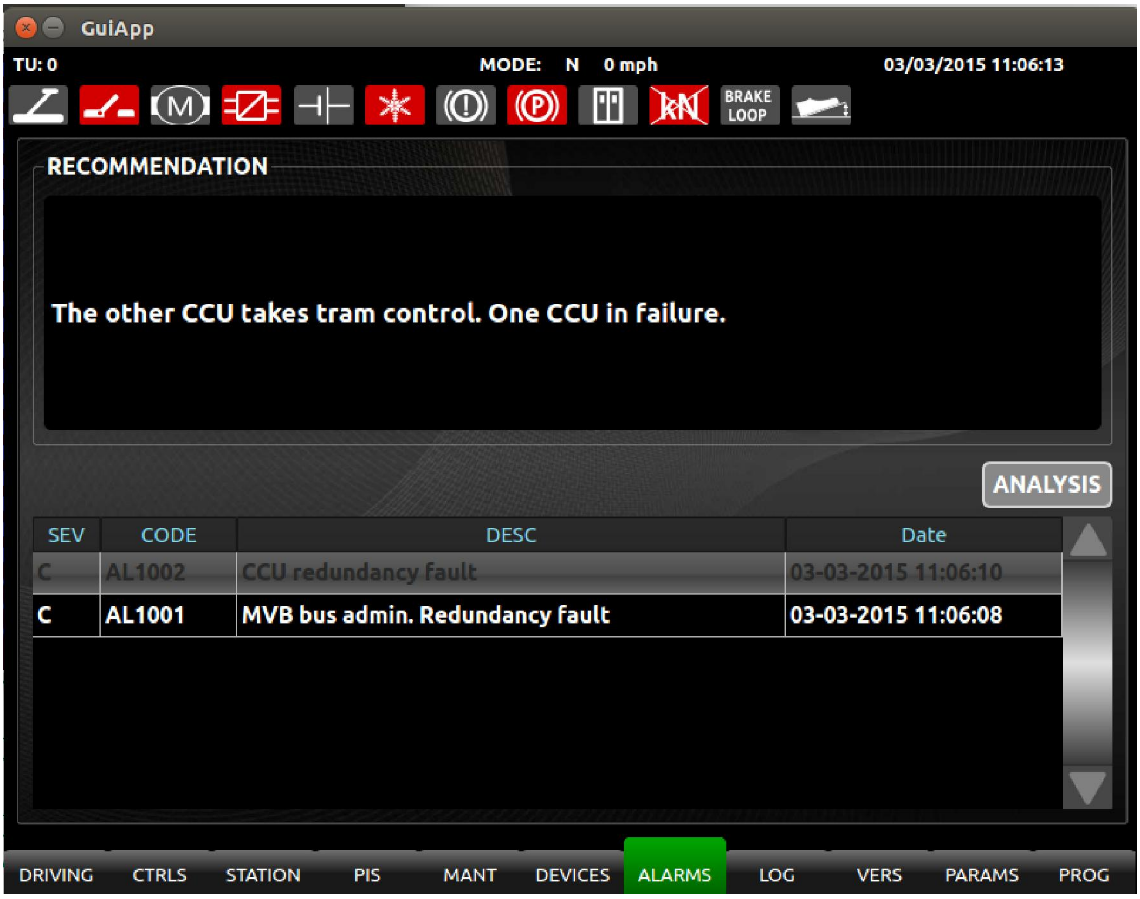


Figure 32 Alarms screen

In the upper part of the screen there is a text box where the recommendation linked to the selected variable of the screen is showed. To select an alarm, just press on it.

The alarms ordering criteria must be selected by pressing the required title on the bar:

- SEV: ordering by alarm severity.
- CODE: ordering by alarm code number.
- DESC: description of the alarm
- TIME: ordering by time criteria.

A second screen will be accessed pressing on the 'VARIABLES' button

Figure 33 Alarms screen - Analysis

This second screen offers the values (in real time) of a series of variables shown in a table. The list of variables is comprised of the variables configured to be recorded related to the selected alarm.

The active operational buttons on this page are the following ones:

- DESCRIPTION: to show the comments associated to the selected variable.

- RETURN: for going back to the first page of the ALARMS screen.

9. PROGRAMMERS SCREENS

Additionally to the maintenance screens mentioned above, the screens to be accessed by high profile user of maintenance staff or programmers are the following ones:

- Log screen (LOG)
- Versions screen (VERSIONS)
- Programming screen (PROG)
- Parameters screen (PARAMS)

9.1 "LOG" SCREEN (LOG)

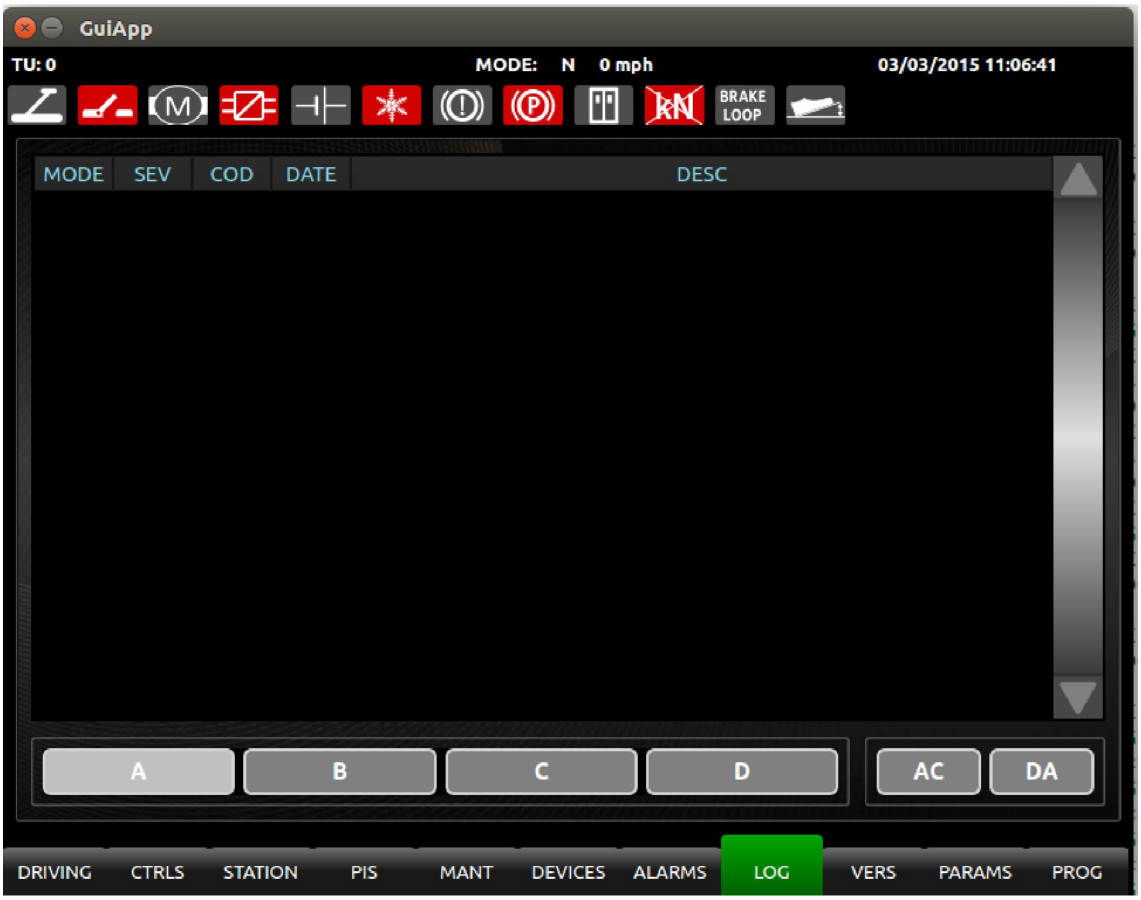


Figure 34 LOG Screen

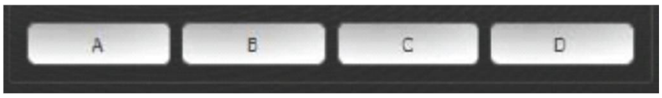
The aim of this screen is to give detailed information about the alarms that have taken place during a certain period of time. The objective is for the maintenance staff to be fully aware of the alarms that have occurred since their last connection, and which have been recorded in the HMI.

This screen is a similar to the STATION screen, except for the fact that this screen has a restricted access and offers information about the activated (and deactivated) alarms that have been recorded in the system shown in the list. So, unlike the STATION screen, the alarms do not disappear from the screen when

they no longer exist. In other words, it does not inform about alarms that are active at that moment in time but it gives a list of the recorded alarms. This information is aimed to the maintenance staff.

Unlike the STATION screen, the list is sorted by date in descending order on this screen, so the most recent alarms appear at the top of the list.

Furthermore, it provides the possibility of showing or hiding the events depending on their severity thanks to the bottom pushbuttons “A” (for events type A), “B” (for events type B), “C” (for events type C) and “D”(for events type D) and “M” (for events type M). If pressed once, the alarms of each type associated with this pushbutton disappear. If pressed a second time, they appear on screen again.



Besides, there is the possibility of showing just the activations and/or deactivations of the alarms. If “AC” virtual pushbutton is pressed once, the activations of the alarms disappear. If pressed a second time “AC”, they appear again. The “DA” pushbuttons functions on the same manner for showing alarms deactivations. To select between activations and deactivations of the alarms, the system has next pushbuttons:

It must be born in mind that the list may be longer than the size of the screen, so it is possible to move above and below these limits using the arrows to scroll through the recorded alarms.

9.2 “VERSIONS” SCREEN (VERSIONS)

The aim of this screen is to inform the maintenance staff about the main software versions of the train; in other words, general information depending on the configuration status of the different devices.

The software versions and the versions of the most important configuration files of the equipment connected to COSMOS-TCMS system can be seen on this screen.

On the table shown in the screen it can be seen the first two columns corresponding to the systems and the software applications that systems include. The following columns represent each car of the vehicle which will be fulfilled with the software versions coding.

If there is no version associated with a system, the cell of the table will be shown empty with grey background.

If, at a certain moment in time, the HMI is not receiving the variable that contains the software version to be shown, it writes three dashes "---" to show that there is no information and it will colour the cell in red.

As the list is longer than the screen capacity to show rows, the system permits vertical movement of the rows of the table using the vertical arrows.

Figure 36 Versions screen

9.3 "PROGRAMMING" SCREEN (PROG)

The aim of this screen is to permit and facilitate the programming tasks, both of the HMI and of the complete COSMOS-TCMS system. It will also help preventive maintenance on providing information about the status of the equipment communication, as well as of the information that is being sent at any given time.

This screen is comprised of a series of different screens that are described below.

9.3.1 'Variable Selection' SCREEN

This screen enables the user to configure the systems variables organized by groups in order to show them on the graphic and tabulated representations.

The variables groups can be created, edited and eliminated, pressing the “Edit group”, “Create group” and “Eliminate” pushbuttons.

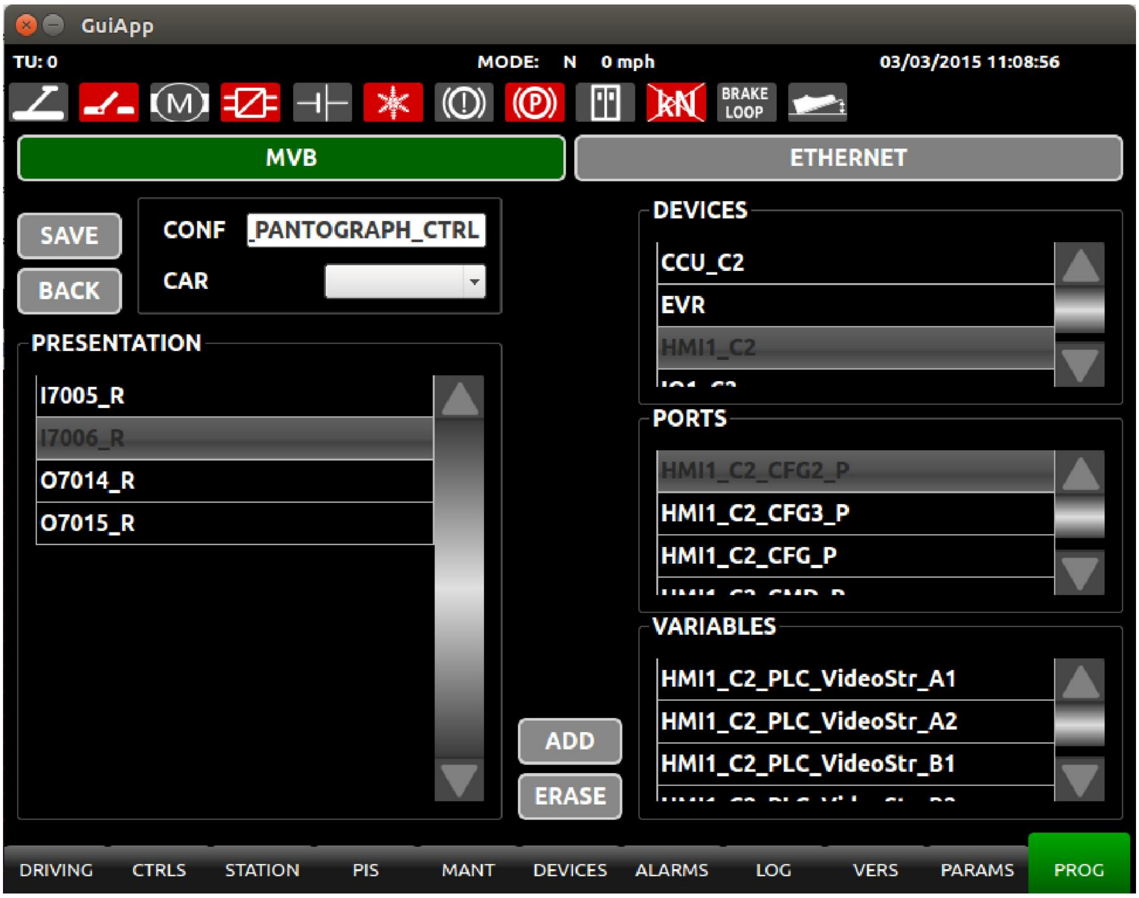


Figure 37 Variable selection screen

Once the user has selected a configuration, the list of variables is activated.

The user can add a new variable to the list, by pressing the “ *ß*” pushbutton. If a new variable is added, the next variable is selected, to deal with it. That means that the selected variable is added to the list if it was not already included.

User can delete a variable from the list, selecting the variable and pressing “ *à*” pushbutton.

The current configuration can be saved with the “***Save***” pushbutton which allows the system to load the current configuration when the user quits the PROGRAMMING screen and enters it again, or even when the HMI is switched off.

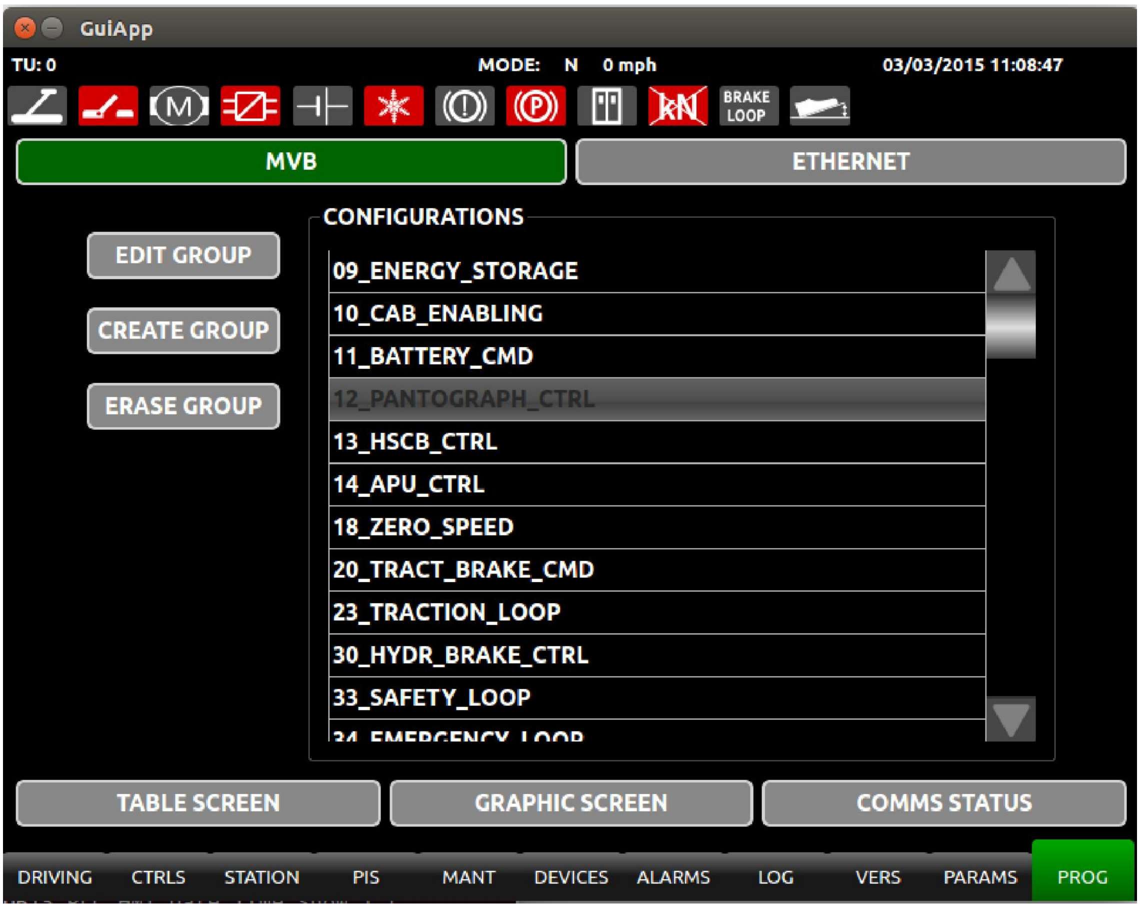


Figure 39 Creating/Editing a group of variables

The Variable selection screen is comprised of three different parts:

- "Table Screen": It switches to the tabulated representation screen.
- "Graphic Screen": It switches to the graphic representation screen.
- "COMM Status": It switches to the communication status screen.

9.3.2 Table screen

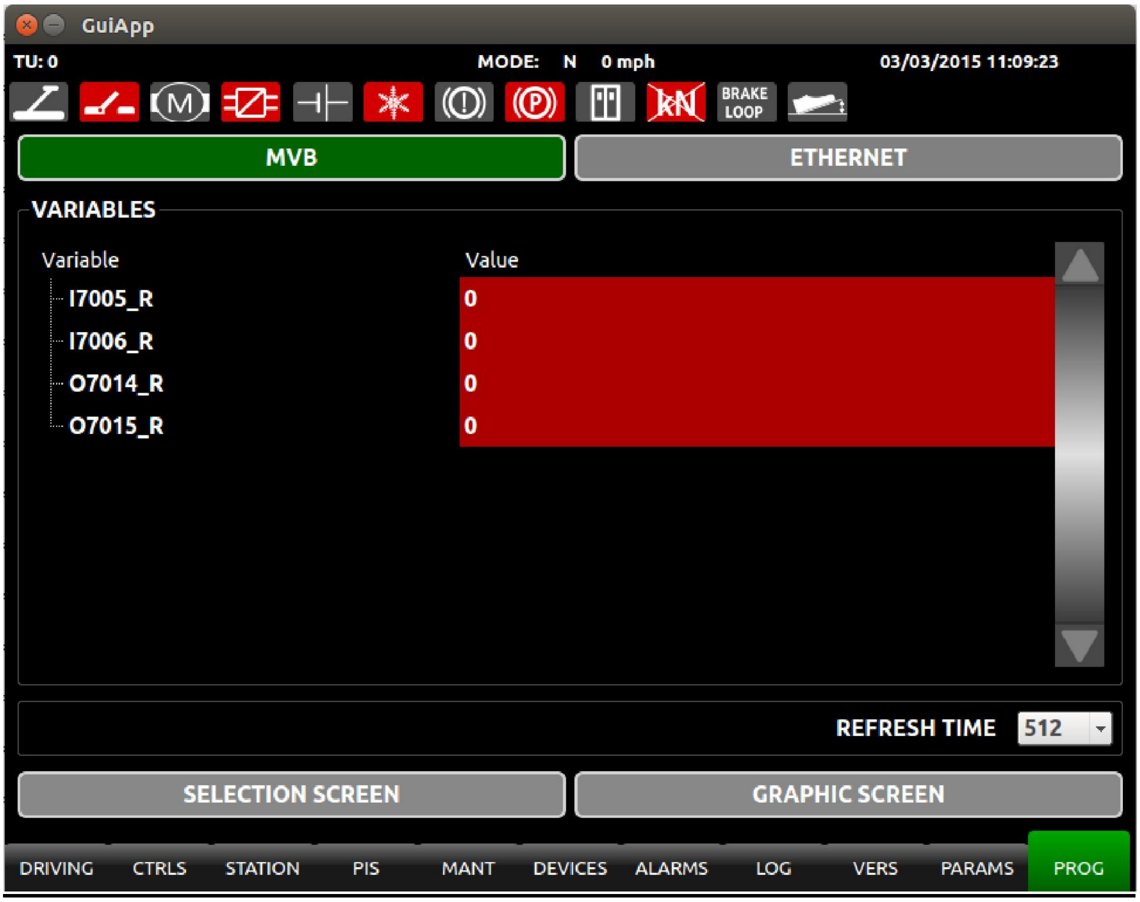


Figure 40 Table screen

This screen presents the list of variables. The list contains a series of variables and their current values, which are continuously updated in agreement with the refresh time defined (see “REFRESH TIME” contextual field). If the list exceeds the presentation capacity, the list can be moved verticallyf horizontal using the arrows bar.

The following information is shown for each variable:

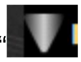
- **Variable (VarName)**: name of the variable in the MVB bus.
- **Value**: value in decimal format (except for BITSET type variables) and in agreement with what the HMI is receiving at any given time. If the quality is bad, the last value read will be maintained and the background of the value box will be coloured red (RGB = 255, 0, 0).

The BOOLEAN type variables are shown with a green background colour (in the value cell) if it is a logic “1”, and blue if it is a logic “0”.

For BITSET type variables, its value will be shown in decimals, with as many digits as the data type contains.

Furthermore, for this type of variables, the screen will show an icon on the left

of the name.

This symbol will be  by default, indicating that it can be rolled down, selecting the variable and pressing the symbol. If the variable is rolled down, each one of the bits of the BITSET are shown as a BOOLEAN type variable (therefore, with background colour according to its value) and the BITSET variable will show the symbol " ", indicating that it can be rolled up.

The name defined for each bit of the BITSET type variable will be shown in the MVB bus, with the text aligned to the right.

The bits of the BITSET variable will be rolled down from lower to higher offset, always starting with offset 0. Therefore, the heaviest bit always appears first (in agreement with the offset definition of the TCN standard).

To roll up the BITSET type variable, it will suffice to select it again and press the "" button again.

9.3.3 Graphic screen

This screen is comprised of a graphic representation control and four pop-down lists of variables.

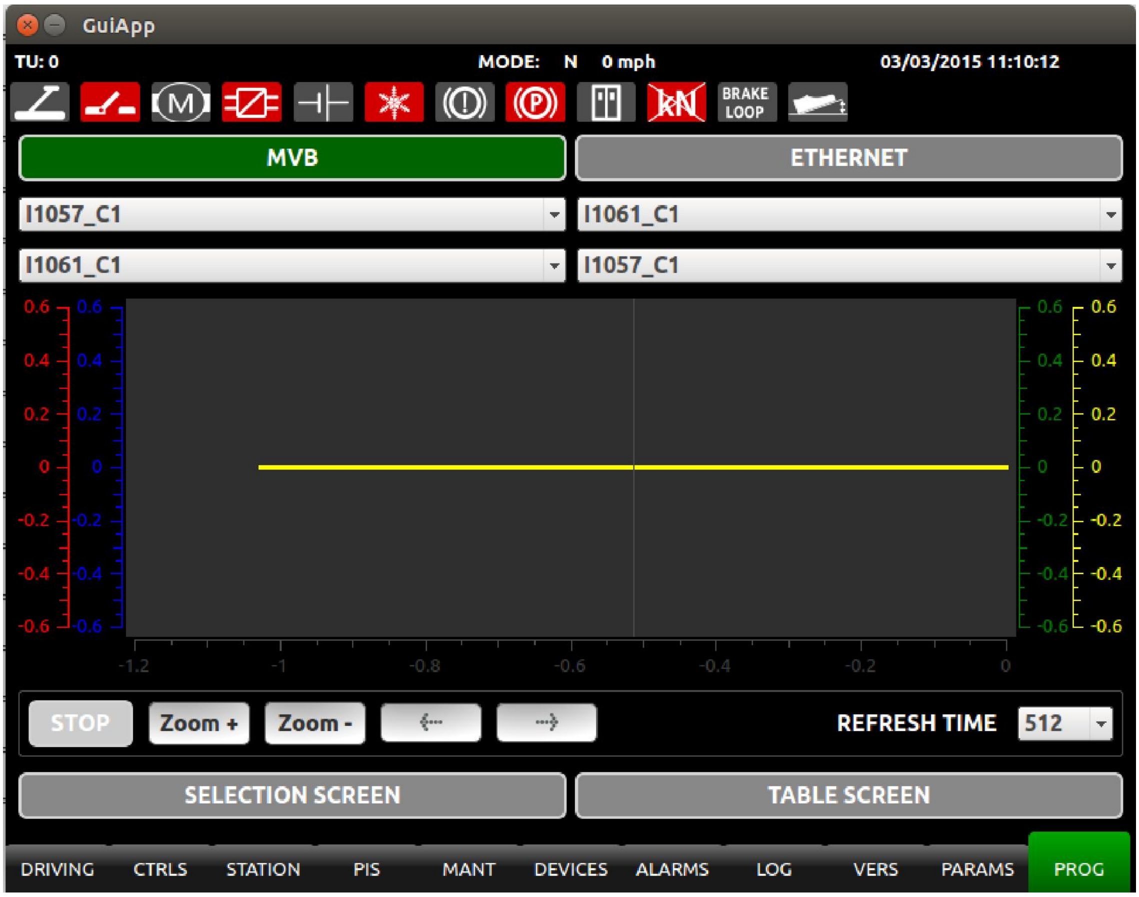


Figure 41 Graphic screen – "Running" mode

Each one of the four lists of variables is associated with a colour that is used to represent the variable selected on this list within the chart. Each list of variables contains the name of the selected variable and the current value.

The screen has two operating modes:

- **RUNNING MODE**:

  The main objective of this mode is to graphically show the current and past statuses of up to four variables. The four selected variables are represented in real time and its values are continuously refreshed (the graphic representation moves to the left). Therefore, the numerical value associated with each list of variables corresponds to the current value.

  From the Running mode, the possible actions to be chosen are the following ones:

  - "**Stop"** to switch to the "STOP" mode
  - "**Selection Screen"** to switch to the variable selection screen.
  - **"Table Screen"** to switch to the tabulated representation screen.

- **STOP MODE**: In this case, the variables selected are not refreshed, but their values are shown on screen for a certain period of time.

  By default, the period of time goes from a few seconds to the moment when the STOP mode was activated. This mode also enables the user to change parameters from this screen (applicable to both modes). In this mode, the values associated with each list of variable correspond to the centre point of the graph.

From the "STOP" mode the user can:

- Select different variables from the lists of variables. The user selects a list of variables. After selecting one of them, if the "down" arrow is pressed, the list of variables increase and then the vertical arrows can be used to select one of the configured variables with graphic representation (see variable selection screen). Each list of variable allows the user to select "none", to not select any variable from this list.
- Change to the Running mode by pressing "Stop" button again.
- Reduce the vertical range of the selected variable by pressing "**Zoom +".** A variable is considered to be selected when its list of variables is active. The minimum vertical range is 1.
- Increase the vertical range of the selected variable by pressing "**Zoom -".** A variable is considered to be selected if its list of variables is active. The maximum vertical range is the maximum range possible of the variable according to its type.
- Increase/decrease the time period (of all the variables) by selecting "**Refresh Time".** The current time period appears on the bottom right of the screen.
- Move the graphic representation (of all the variables) to the right, reading the previous values, pressing the key "ß". If the oldest values

are reached, the cursor moves to the left and the current values on the lists of variables correspond to the values of the position of the cursor.

- Move the graphic representation (of all the variables) to the left, reading the newest values, pressing the key "à". If the newest values are reached, the cursor moves to the right and the current values on the lists of variables correspond to the values of the position of the cursor.

- Switch to the variable selection screen by pressing "**Selection Screen"** or switch to the table screen by pressing "**Table Screen**".

The first time the user enters this screen, the variable lists contain the first four variables configured with graphic representation. If the user quits the screen and reaches it again, the variables selected will be the same as those that were selected the last time that the user quit the screen, and with the same display configuration (offset, time, etc.). If any of them are not configured in graphic representation, **"none"** will be selected.

9.3.4 Communications status screen

The aim of this screen is to show detailed information about the communications of a device. It shows the status of all the ports published by a certain selected device (on the DEVICES screen).

The selected device appears in the upper left-hand corner of the screen.

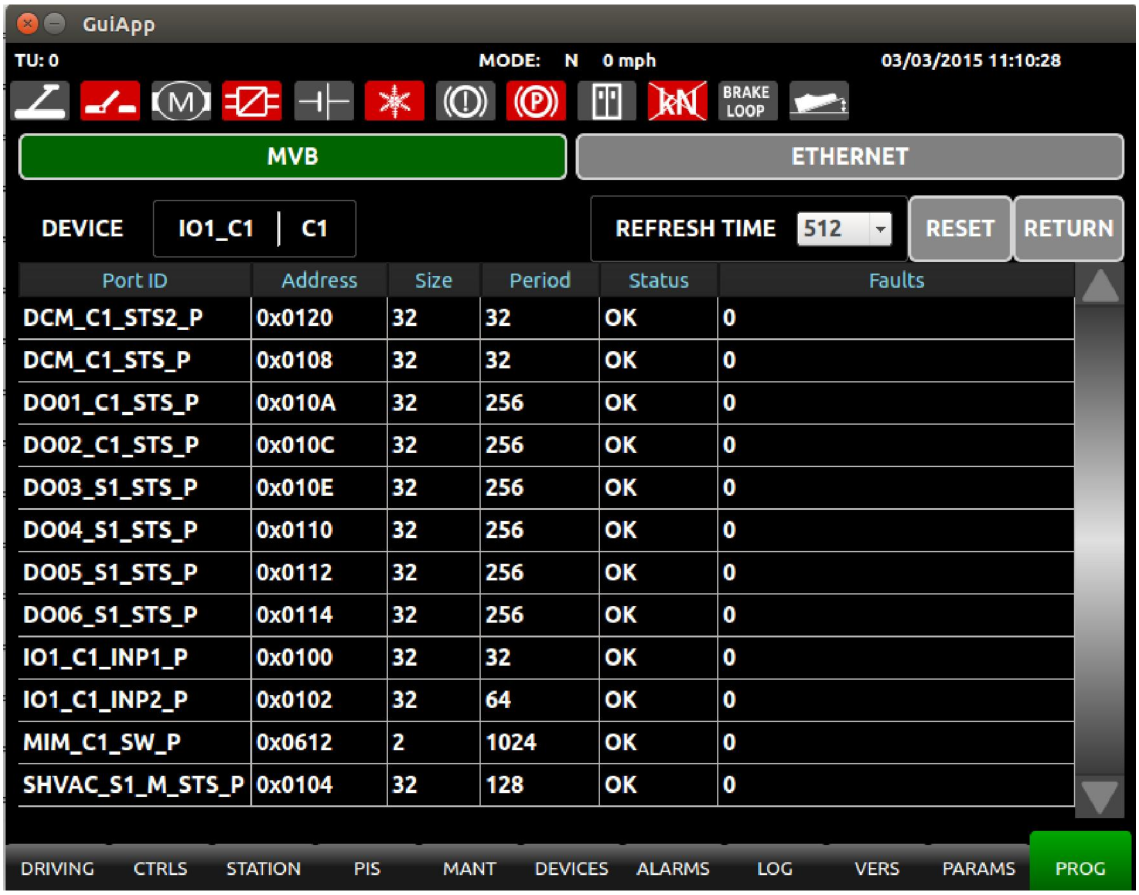


Figure 43 Communication status screen

The main part of the screen consists in a list with the ports published by the device analysed. Each row has the following fields:

- **PortID:** Name of the port
- **Address**: Logical address of the port in MVB.
- **Size**: Size of the port in number of bits.
- **Period**: configured period (in milliseconds) of the port publication. The STS should never be greater than this period. If this occurs, an error is counted.
- **Status**: port reception time supervision (time in milliseconds since the last time the port was received). This value is continuously refreshed. The possible values are:
    - OK: the current STS is less than twice the port period.

- NO OK: the current STS is twice the port period or greater. This status means that the background of the row turns red. Every time the port reaches this status, the error counter increases by one.

- Errors: number of errors counted since the last time the counter was reset or this screen was entered.

The ports included in the list are sorted by increasing order of the logical address of the ports.

Finally, the user may also:

- Reset the number of errors by pressing “RESET” button.

- Change to the variable selection screen by pressing “RETURN”.

9.4 “PARAMETERS” SCREEN (PARAMS)

The aim of the PARAMETERS screen is to inform and permit changing a series of parameters that may change in the unit during the maintenance tasks.

Different types of parameters are shown on this screen, organised into two pages within the same screen (page 1 and page 2).

9.4.1 Parameters screen (page 1)

On the upper part of first page are shown show the parameters than can be modified through the configuration file in the CCU.

This permits controlling the current values through one version, as well as easily modifying them without losing proper control.

These parameters could be (configurable):

- Delay time (automatic closing) after opening.
- The acoustic pre-warning time before closure.
- Number of door reversing sequences (closing direction).
- The waiting time to re-attempt to close them by timing.
- The waiting time to re-attempt to close them by pushbutton.
- Emergency unlocking pulse time.
- SHVAC Point Low, interior temperature.
- SHVAC Point Low, exterior temperature.
- SHVAC Point High, interior temperature.
- SHVAC Point High, exterior temperature.

In this screen it can be also shown five parameters of the vehicle which must be fixed during the project development stage. These parameters must be selected from the different variables published in the communications bus of the streetcar (for example, the total kilometres run by the vehicle).

This page lets change date and time.

Finally there are three indicators showing the current car weight values supported by each truck (C1, R and C2).

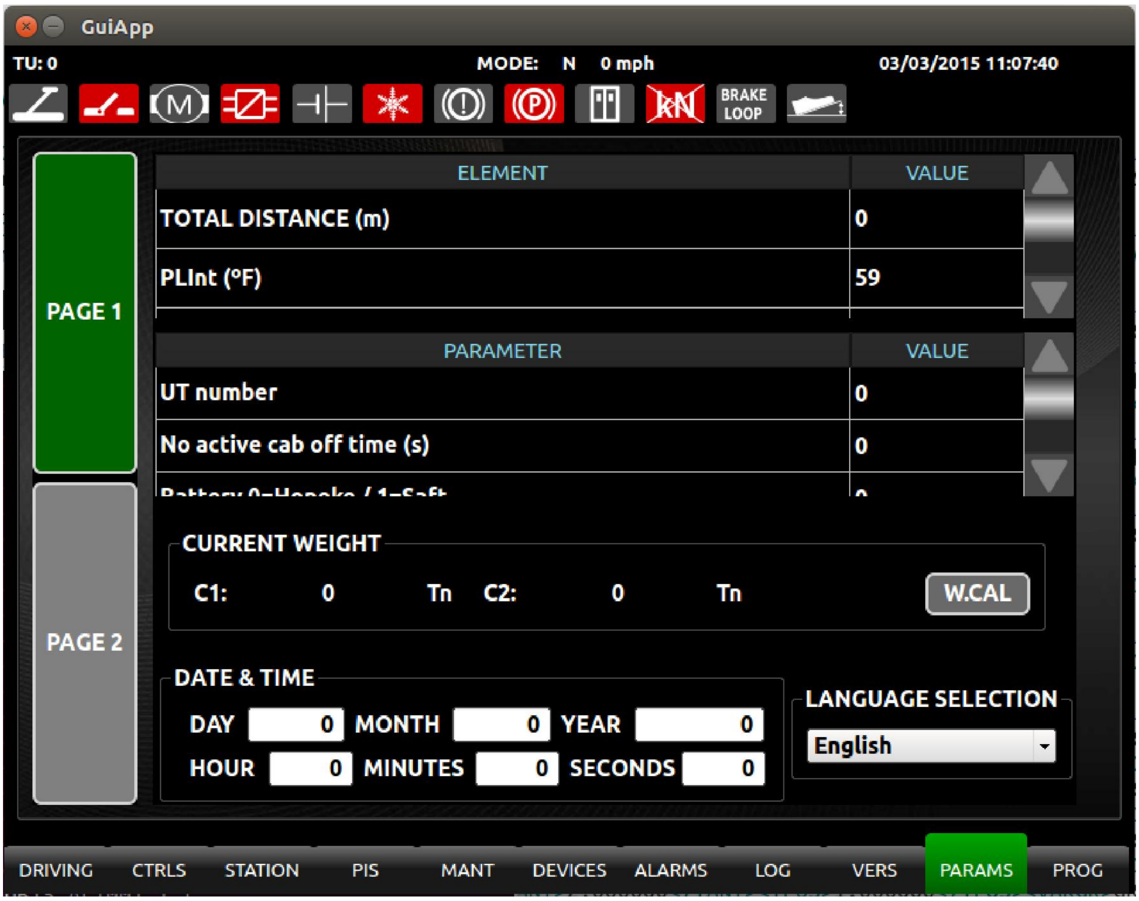


Figure 44 Parameters screen - page 1

To make any changes, just select the text box whose value is required to be changed and enter the data using the numbers of the numerical keypad. The background of the selected box will change the colour and will enable entering a new data.

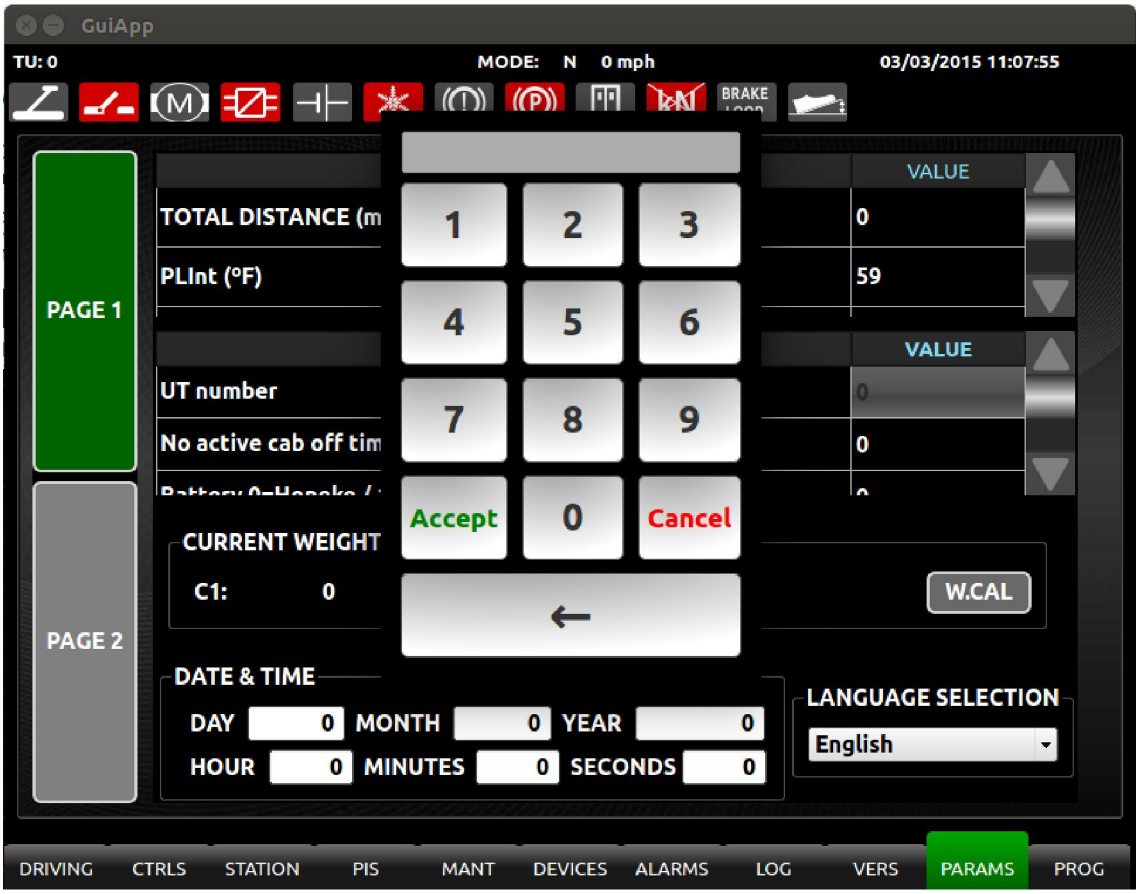


Figure 42 Parameters screen – changing parameters

If, on the contrary, this process has begun, pushbutton "***Cancel***" will cancel the change in process (maintaining the previous value).

Once the change of a parameter has started, this is validated by pressing the "***Accept***" pushbutton. The system will recognise the validity of the parameter entered and if it is not valid (does not satisfy the pre-established value range or format), it will be cancelled returning to the previous value .

"***C***" pushbutton lets correct the value entered via keypad.

9.4.2 Parameters screen – Wheel diameters (page 2)

The wheel diameters of the unit can be modified on this second page of the parameters screen.

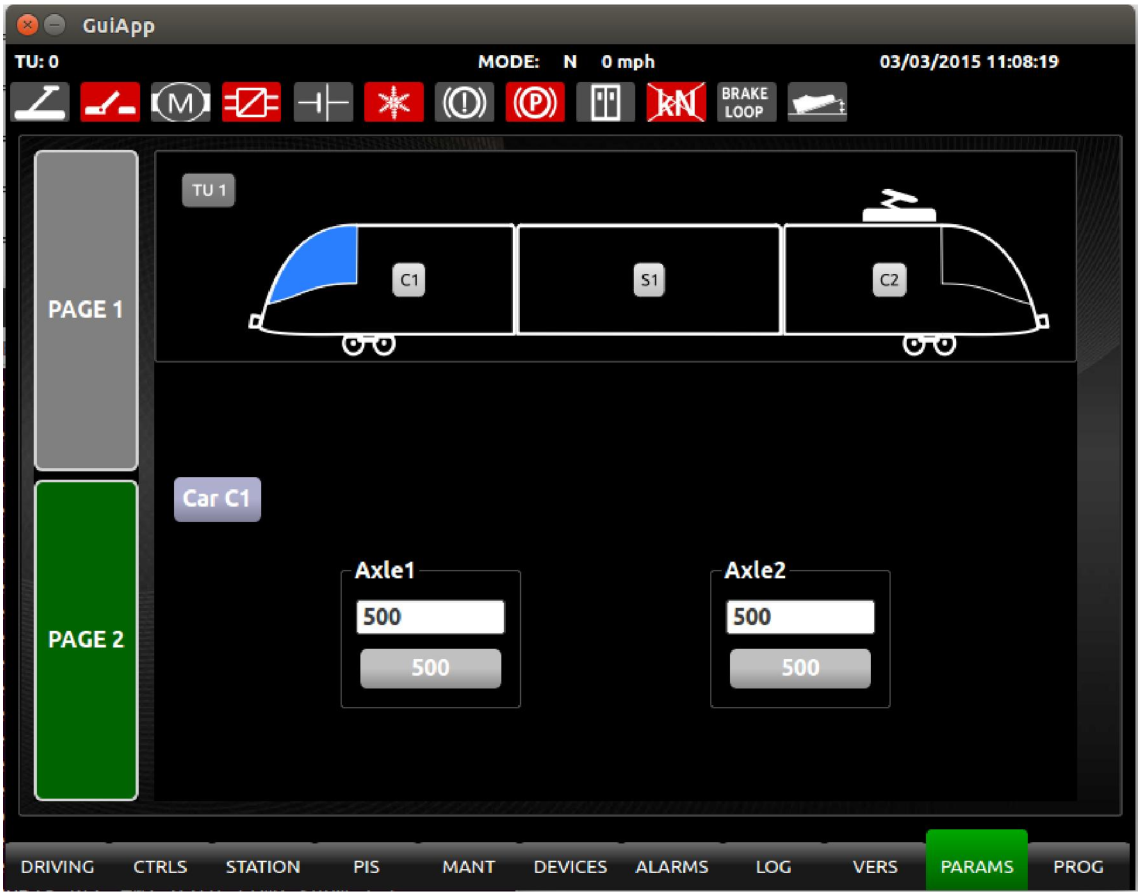


Figure 43 Wheel Diameter page

To change the value of a wheel diameter, select the respective box and enter the new value. The system will indicate that the change in value is permitted when the box colour background has changed.

The system will validate the data, admitting them if they are in the appropriate range.

Likewise, the change can be cancelled by pressing "***Cancel***", and the value written will be entered by pressing "***Accept***".

APPENDIX 14.3

TRAIN SQAP

REVISION RECORD

ISSUE	MODIFICATION	DATE

Prepared: **Name:** **Signature:** **Date:**	**Reviewed:** **Name:** **Signature:** **Date:**	**Approved:** **Name:** **Signature:** **Date:**

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1. PURPOSE AND SCOPE

1.1. PURPOSE

Purpose of this document is to identify CAF's approach to Software Quality Assurance for the project.

This document has been written in accordance with the requirements defined at Table A.2 of IEEE Std. 1558TM-2004 [Ref.4], with EN50128 standard [Ref.3] and with CAF procedures that are compliant with both ISO9001 and IRIS (International Railway Industry Standard).

This Software Quality Assurance Plan (hereinafter SQAP) is an integral part of the overall Train Quality Plan [Ref.21].

1.2. SCOPE

This document must be attended by CAF as train integrator and also by Subsystems' Suppliers (CAF included as Train PLC programmer) that provide systems that use a software application to perform their functionality.

This includes software systems for control, monitoring, diagnostics, portable or bench test equipment, and wayside data analysis. Also items that may be considered firmware and systems that include data configurable files must comply with these requirements.

It is applicable to the whole software life-cycle.

Please note that CAF follows a strategy top-down for software quality assurance, which has a two tiered approach that will be fully detailed along this document:

1. TRAIN level, which is CAF's responsibility and considers the documents with the common procedures to be complied by all Subsystems and the activities related to Subsystems' integration and overall train validation.

2. SUBSYSTEM level, which is Suppliers' responsibility and includes Subsystems' software documents with the detail of software configuration items (hereinafter SCI) that compose the subsystem, the activities related to their development, the way they are tested, their integration into the hardware and the validation of the final Subsystem product at Suppliers' facilities.

1.3. SQA OBJECTIVES

Software does not exhibit random failures in the manner that may be expected of systems that would traditionally deliver these functions (where such functions would be achievable in traditional technology). Software delivers the logical processes that are embedded within its coding. The software does not fail to process this coding. Software ‘failures’ are, in fact, failures of the software to deliver the required function, either due to an inadequacy in the coding (a systematic failure), or a random failure of the hardware on which the software runs to process the code.

The ‘reliability’ of software (its ability to deliver its required functions in a repeatable way) is therefore dependent on the robustness of the processes that have been applied to its development, that is, the software quality assurance procedures, which include such elements as:

- Identification of safety functions (if existent) and
- Allocation of appropriate Software Safety Integrity Level (SIL) to safety functions
- Planning of software architecture
- Use of software modules with known proven history, where available and appropriate
- Identification of possible combinations of inputs and outputs
- Application of proven coding languages and processes
- Reviews throughout the development process
- Application of proven testing processes and tools
- Independent (third party) assessment where appropriate.

So, software quality assurance objectives are:

- To provide a reasonable degree of confidence to the final user that product acquires its required attributes during software development
- To demonstrate that the software performs its required functionality (and only that one), in a reliable and repeatable way
- To demonstrate that CAF acted in a reasonable and professional way when developing software and when integrating it into the train.

1.4. SOFTWARE CONFIGURATION ITEMS

This plan applies to all project's Software Configuration Items (hereinafter SCI).

Suppliers will define into their SQAP documents (see [Ref.31] and [Ref.32]) the SCIs per Subsystem basis.

1.5. APPLICABLE LIFE CYCLE PHASES

Present plan is applicable to whole train life-cycle:

- Planning
- Specification
- Concept - Architectural design
- Development
- Integration (Verification)
- Prototype production
- Pilot-series (Validation)
- Series production
- Installation, setting into operation
- Operation
- Repair, remove of faults
- Maintenance / modification

Attending to CAF top-down approach and to the previously identified two levels (train and subsystem) this life-cycle model is in fact composed by a set of life-cycles; one that is fully CAF's responsibility as train manufacturer (integrator) role, and then a life-cycle per every subsystem's software development.

CAF recommendation for software life-cycle is the "V" model defined at EN50128 standard (see [Ref.3]). Please note that in case software has any Safety Integrity Level assigned according to EN5012x standardization then this recommendation is in fact mandatory.

For not safety-related software the life – cycle defined at Figure 1 of IEEE Std.1558-2004 (see [Ref.4]) may be also used if Supplier is more familiarized with IEEE standardization.

Life-cycle stablished per every software must be fully defined at Subsystem SQAP (see [Ref.31] for sub-suppliers and [Ref.32] for CAF's PLC) following these recommendations.

1.5.1. Integration of software life-cycle in the train life-cycle

The purpose of this section is to explain how is made the integration of software life-cycle in the product (train) life-cycle.

In terms of life-cycle a double "V" approach is followed by CAF in order to assure that software is always aligned with train design.

In the Figure 1, the "blue V" is the one corresponding to the Train design Level. And the "yellow V" corresponds to the software development of the different sub-systems (CAF PLC included).

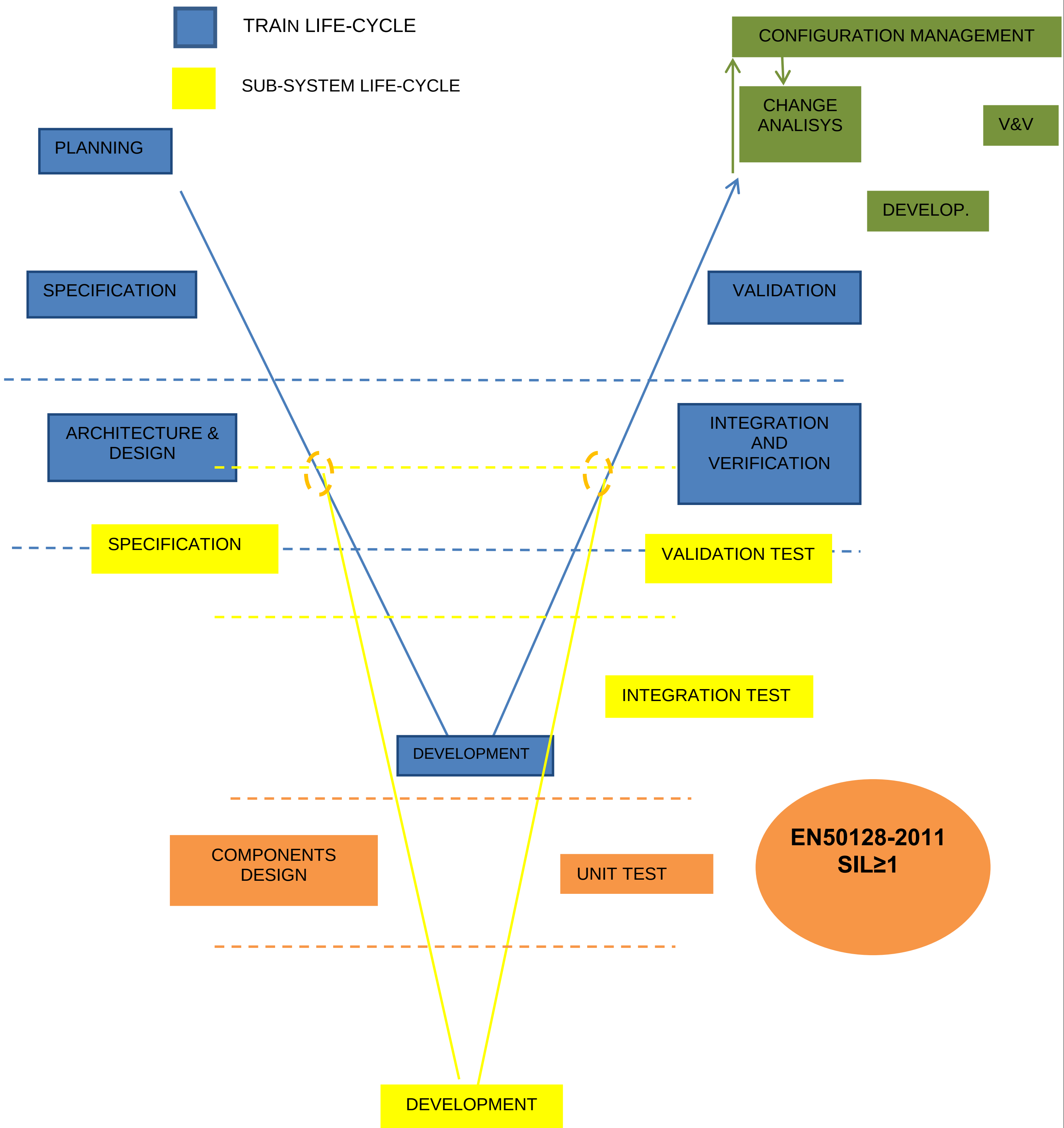

Figure 1: *Software and train life-cycle integration*

2. REFERENCES

In this section they have been included the references of standardization and documents applicable to Train Level, that is, related to CAF's responsibility as train manufacturer.

The sets of references per subsystem basis will vary depending on its Software Quality approach, which will depend on standardization and safety requirements (if applicable to system). They will be full defined at Subsystem SQAP (see [Ref.31] for sub-suppliers and [Ref.32] for CAF's PLC)

2.1. INTERNATIONAL STANDARDS

Ref.	Code	Title
[Ref.1]	ISO-9001:2008	Quality Management Systems. Requirements
[Ref.2]	IRIS	International Railway Industry Standard
[Ref.3]	EN50128:2011	Railway applications. Communications, signaling and processing systems. Software for railway control and protection systems.
[Ref.4]	IEEE Std 1558™-2004	IEEE Standard for Software Documentation for Rail Equipment and Systems
[Ref.5]	IEEE Std 730™-2002	IEEE Standard for Software Quality Assurance Plans
[Ref.6]	ISO-9000-3	Software engineering -- Guidelines for the application of ISO 9001:2000 to computer software

Table 1: *References: International Standards*

2.2. CAF PROCEDURES

Ref.	Code	Issue	Title
[Ref.10]	N-07.03-BZ-04	A	Software Quality Assurance (SQAP) included in EEFAE's
[Ref.11]	N-07.03-BZ-03	B	Configuration Management of microprocessor based EFAEs
[Ref.12]	Mod. 07.03-BZ-11	-	Software Configuration List
[Ref.13]	Mod. 07.03.BZ-03	A	Request for Modification
[Ref.14]	N-06.02-BZ-04	A	BDI Documentation Control guideline
[Ref.15]	N-05.02-BZ-03	H	Article codification and groups' guideline

Table 2: *References: CAF Standards*

2.3. PROJECT DOCUMENTATION (INPUTS TO LIFE CYCLE)

Ref.	Code	Title
[Ref.20]	---	Customer Technical Specification
[Ref.21]	X.XX.96.100	Train Quality Assurance Plan
[Ref.22]	X.XX.96.900	Train Safety Plan
[Ref.23]	X.XX.94.362.nn(1)	TCMS technical documentation
[Ref.24]	---	CAF's Project (internal) Development Schedule

Table 3: *References: Inputs to Life Cycle*

2.4. PROJECT DOCUMENTATION (OUTPUTS OF LIFE CYCLE)

Ref.	Code	Title
[Ref.30]	X.XX.98.001.00	Train Software Quality Assurance Plan
[Ref.31]	X.XX.98.8EE.0S(2)	Subsystem Software Quality Assurance Plan
[Ref.32]	X.XX.98.100.00	CAF's PLC Software Quality Assurance Plan
[Ref.33]	X.XX.96.905	Safety Functions (SIL) Definition
[Ref.34]	X.XX.96.906	Architecture SIL Apportionment
[Ref.35]	X.XX.96.903	Hazard Log
[Ref.36]	X.XX.96.999.nn(1)	Safety Cases
[Ref.37]	---	BERDE (including Train Design Review Report)
[Ref.38]	X.XX.75.9nn.nn(1)	Train Functional Descriptions
[Ref.39]	X.XX.98.101.nn(1)	HMI Screens Specification documents
[Ref.40]	X.XX.98.108.nn(1)	Communication Interface Specification documents
[Ref.41]	X.XX.98.7EE.0S(2)	(Systems) Communication Interface Specification cbc
[Ref.42]	X.XX.94.3EE.0S(2)	Systems Technical Descriptions
[Ref.43]	X.XX.92.nnn.nn(1) X.XX.92.162.nn	Type Test Protocols Communications Integration Type Test Protocols and Reports
[Ref.44]	X.XX.98.3EE.0S	System Software Configuration List
[Ref.45]	X.XX.97.400.00	Operator User's Manual
[Ref.46]	X.XX.97.500.00 X.XX.97.5nn.nn(1)	Maintenance Plan Maintenance Manuals

Table 4: *References: Outputs of Life Cycle*

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(1) *n goes from 0 to 9 (indicate that a set of documents may exist)*
(2) *EE stands for the two last codes of EFAE (Fundamental external stock element). S stands for the sub-code used at some EFAEs (if not 0)*

3. MANAGEMENT

3.1. ORGANIZATION

Train level

CAF organizational structure related to the assurance of (train) software quality and safety is depicted in this figure:

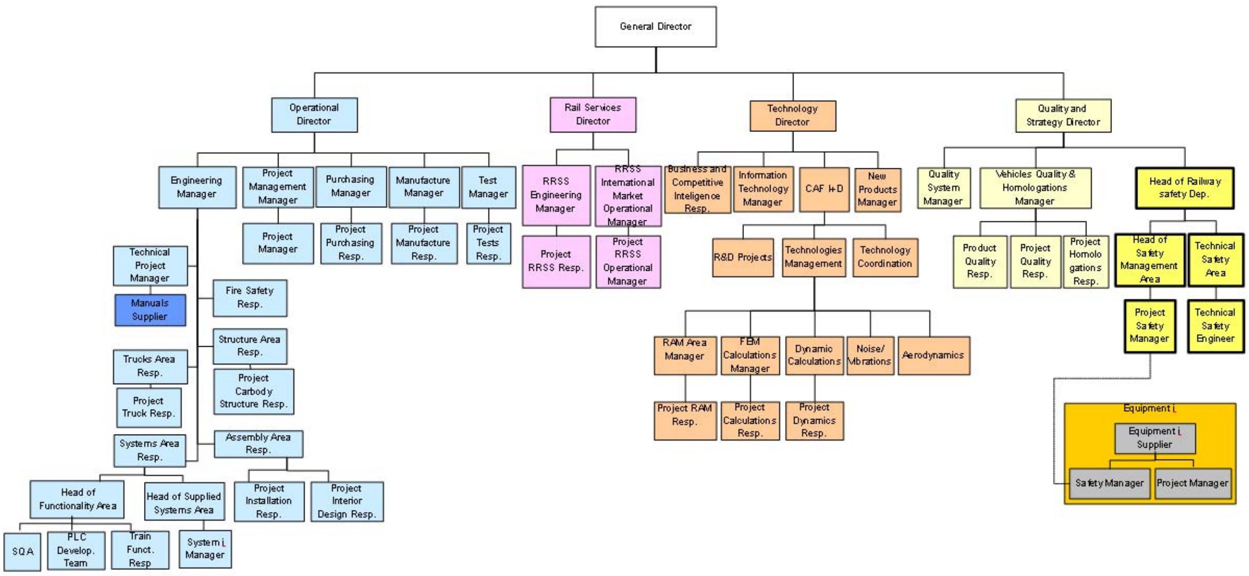


Figure 2: *CAF organizational units influencing and/or controlling Train software quality and safety*

Reporting to the Engineering Manager there is the Systems Area, which has the following roles:

a) The engineer responsible of train functionality, which is the one to collects all train functional requirements, perform the train concept-architectural design, and allocate train functionality into subsystems and schematics.
b) The people responsible of integration of Subsystems purchased to sub-suppliers into the train (Systems' Managers), which will be the ones to:
   a. Inform to Suppliers about the requirements allocated to their sub-systems
   b. Request and Review Suppliers documentation
   c. Write documents related to subsystems' integration into the train, as functional descriptions, validation tests, etc.
   d. Assist to tests developed at Suppliers facilities (partial validation) and to type tests performed at train (final subsystem validation)
c) The people responsible of developing CAF's PLC software, which will have same tasks as if they will be another system sub-supplier
d) The people responsible of controlling that software quality practices are being performed in an appropriate way along the project, that is, that this SQAP is complied. They are also the responsible of writing present document.

When train is at warranty or maintenance period the people that assume the roles of Systems Area there are those of Rail Services Engineering Area.

Also reporting to the Engineering Manager there is the Technical Project Manager, which will be the engineer to have a close contact with the Client and so the one to manage the interchange of information between Client and CAF departments. He or she will perform also some documentation verification tasks

Reporting to the Operational Director at Purchasing Area, there are the people responsible of assuring that sub-Suppliers comply with all their duties.

Also reporting to the Operational Director, at Manufacture Area, there is the Test Department, which are the people responsible of performing train testing, that is, to check if functionality has been reached satisfactory over the real target.

Reporting to the Vehicles Quality & Homologations Manager, there is the Project Quality Responsible, which will be the train validator for the non-safety functionalities

Reporting to the Head of Railway Safety Department there are the people responsible of performing train safety analysis and apportioning safety functions to sub-systems. Project Safety Manager will be the validator of safety functions.

Subsystem level

Organization per Subsystem basis must be included at Subsystem SQAP (see [Ref.31] for sub-suppliers and [Ref.32] for CAF’s PLC).

Please note that in case software has any Safety Integrity Level assigned according to EN5012x standardization then Organization must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

3.2. TASKS

3.2.1. SQA Tasks

Herein a brief summarize of phases and tasks depending on the train/subsystem level.

PHASE	TRAIN LEVEL TASKS	SUBSYSTEM LEVEL TASKS
Planning	- Train Software Quality Assurance planning - Review	- Subsystem Software Quality Assurance planning - Assessment plan (if applicable) - Review
Specification	- Allocate train functional requirements (high level) into CAF Requirements Management System - Identify safety functions (and their SIL) - Review	- Subsystem Software Specification - Review
Architecture and Design	- Define Train Architecture - Apportion Safety Functions (and their SIL) to Subsystems (if applicable) - Define buses protocols - Define HMI screens - Review	- Subsystem Software Architecture and Design - Components Design (if applicable) - Review
Development	- Buses configuration - HMI screens - Review	- Subsystem SW coding - Configure Subsystem Databases (if applicable) - Review
Integration	- Communications tests - Review	- Module tests (if applicable) - SW integration tests - HW / SW integration tests - Review
Validation	- Type tests - Review - Train base-line - Subsystems Safety Cases (if applicable)	- Software validation tests at Suppliers facilities (bench tester) - Review - Assessment report (if applicable) - Subsystem base-line
Installation, setting into operation	- Operator User Manual (including safety related issues if applicable) - Review	- Software tools for operation and maintenance - Software User Manuals - Review
Maintenance/ Modification	- Subsystems' Modification Requests - Updating of train base-line	- Subsystem Configuration Management internal procedures - Updating of Sub system base-line - Review

Table 5: *Software Quality Assurance Tasks*

Please note "Review" is included to indicate verification tasks in all phases.

Train level

Herein a more detailed description about train related tasks including responsibilities and entry and exit criteria.

Two tables have been included; first one with common software quality procedures and second with the specific safety-related tasks and/or the change of responsible for the common software procedures in case of safety.

Phase	Entry Criteria	Exit Criteria	Roles and Responsibilities	
			Preparing	Reviewing
Planning	These documents available: - Train Quality Assurance Plan - Train Safety Plan - CAF SW standard procedures - Contractual Project Technical Specification	Train Soft. Quality Assurance Plan (SQAP) created and reviewed	Project SQA responsible	Head of (Software) System's Area
Specification	Customer Technical Specification available	BERDE with train (high-level) requirements	Train Functionality Responsible	Technical Project Manager
	BERDE updated	Train Design Review Report	Technical Project Manager	---
Architecture and Design	BERDE reviewed	- Definition of Train Architecture with subdivision into sub-systems and schematics - Train Functional Descriptions	Train Functionality Responsible	Technical Project Manager
	These documents available: - BERDE reviewed - Train Functional Descriptions	Systems Technical Descriptions	System Suppliers	System Managers
	TCMS Technical documentation (buses specification) available	Communication Interfaces Specification	TCMS System Manager	Project SQA responsible
	Communication Interfaces Specification	(System) Communication Interfaces Specification clause by clause	System Suppliers	System Managers

Phase	Entry Criteria	Exit Criteria	Roles and Responsibilities	
			Preparing	Reviewing
	These documents available: - TCMS Technical documentation (including HMI technical spec.) - Train Functional Descriptions - Systems' Technical Description	HMI Specification	TCMS System Manager	Train Functionality Responsible
Development	These documents available: - Communication Interfaces Specification - Train Functional Descriptions - Systems' Technical Description	(Systems) Buses Frames/Ports definition documents created and reviewed	TCMS System Manager	System Managers
Development	These documents available: - HMI Specification - Train Functional Descriptions - Systems' Technical Description	HMI Configuration created and reviewed	TCMS System Manager	Train Functionality Responsible
Integration	These documents available: - Communication Interface Specification - (Systems) Buses Frames/Ports definition documents	These documents created and reviewed: - Communications integration verification test protocols - Communications integration verification test reports	TCMS Supplier	TCMS System Manager
Validation	These documents available: - Train Functional Descriptions - HMI Screens Specification	(TRAIN) type test protocols created and reviewed	Train Functionality Responsible	Technical Project Manager
Validation	System Technical Description available and reviewed	(System) type test protocols created and reviewed	System Supplier	Technical Project Manager
Validation	Type test protocols available	Type test reports filled and reviewed	CAF Testing Department	CAF Quality Department
Validation	Validation process ended	Train Software base-line created as a set of Systems' Software Configuration Lists	SQA people	CAF Quality Department

Phase	Entry Criteria	Exit Criteria	Roles and Responsibilities	
			Preparing	Reviewing
Installation / Setting into Operation	These documents available: - Train Functional Descriptions - HMI Screens Specification - Systems Manuals	Operator User Manuals	Technical Project Manager	Train Functionality Responsible, Systems Managers
Maintenance and Modifications	System Modification Request	System Modification Request Validated	System Manager	CAF Testing Department
	System Software base-line Updated	Train Software base-line updated	SQA people	CAF Quality Department

Table 6: No safety software Life-Cycle (train level)

Phase	Entry Criteria	Exit Criteria	Roles and Responsibilities	
			Preparing	Reviewing
Planning	These documents available: - Train Quality Assurance Plan - Train Safety Plan - CAF SW standard procedures - Contractual Project Technical Specification	Train Soft. Quality Assurance Plan (SQAP) created and reviewed (include software safety plan)	Project SQA responsible	Project Safety Manager
Spec.	System functional breakdown document available	Safety Functions (SIL) Definition document	Technical Safety Engineer	Project Safety Manager
Architecture and Design	Safety Functions (SIL) Definition document available	Architecture SIL Apportionment	Technical Safety Engineer	Project Safety Manager
	Architecture SIL Apportionment available	BERDE updated	Project Safety Manager	Technical Project Manager

Phase	Entry Criteria	Exit Criteria	Roles and Responsibilities	
			Preparing	**Reviewing**
	Architecture SIL Apportionment available	Evidence of Functional Safety, which includes Systems Technical Descriptions including its Safety Concept	System Supplier Technical Safety Engineer	Project Safety Manager
Validation	These documents available: - Train Functional Descriptions - HMI Screens Specification	(TRAIN) type test protocols created and reviewed	Train Functionality Responsible[3]	Technical Project Manager[4]
Validation	(System) Technical Description available and reviewed	(System) type test protocols created and reviewed	System Supplier	Technical Project Manager[4]
Validation	Type test protocols available	Type Test Reports filled and reviewed, and Hazard Log updated	CAF Testing Department	Project Quality Manager in general, and Project Safety Manager for safety related test cases
Validation	Validation process ended	System Safety Case	Systems Supplier	Project Safety Manager
Installation / Setting into Operation	These documents available: - Train Functional Descriptions - HMI Screens Specification - Systems Manuals - Safety Cases (section SRAC)	Train Users Manuals including Safety related issues	Technical Project Manager	Project Safety Manager
Maintenance and Modification	System Safety Modification Request	System Modification Request Validated	System Manager	Project Safety Manager
Maintenance and Modification	System Software base-line Updated	Train Software base-line updated	SQA people	Project Safety Manager

Table 7: *S*oftware safety-related (additional) tasks

3 Technical Safety Engineer may request to add additional safety-related test cases.
4 Project Safety Manager checks that safety requirements have been included in tests cases

Subsystem level

A detailed description of tasks per Subsystem basis must be fully included at Subsystem Software Quality Assurance Plan (see [Ref.31] for sub-suppliers and [Ref.32] for CAF's PLC).

Please note that in case software has any Safety Integrity Level assigned according to EN5012x standardization then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

If not, then the Supplier must comply with another recognized standard as ISO 9000-3 or IEEE Std 1558^{TM}-2004.

Selected approach and standardization compliance must be defined at Subsystem SQAP.

Please note that Subsystem SQAP will include only the tasks performed by the Supplier.

Apart from them, CAF as train integrator will perform a Subsystems' documentation verification, which may be a) the revision of all Subsystem's documents or b) the revision of Subsystem's Safety Case and/or EN50128 certified assessor report (if applicable).

Case b) is applicable for a Subsystem with a SIL higher than 0 (according to EN5012x standardization) whereas case a) applies in the rest of situations.

CAF organization involved in this verification role is:

- Systems' Managers for case a). Please note they have the support of people specialized in software quality at Systems' area for software issues
- Project Safety Manager for case b)

3.2.2. Tasks milestones and Schedule

They are defined within CAF's Project Development Schedule (see [Ref.24]).

3.3. ROLES AND RESPONSIBILITIES

Roles and responsibilities per task have been defined at section 3.2.1.

3.4. QUALITY ASSURANCE AND ESTIMATED RESOURCES

This information is confidential and must not be published extern to CAF.

4. DOCUMENTATION

CAF as an ISO9001 and IRIS accredited enterprise has a set of standard procedures defined for documentation format, control, distribution and storing (among others).

This set of standard is too extensive to be listed in this document, but some examples are given here as reference:

- Technical documentation (as this document is) follows the model 06.02-BZ-06, configuration list for software the model [Ref.12], request for modification the model [Ref.13], and so on.

- CAF standard N-06.02-BZ-06 defines for every document the people responsible of its writing, reviewing, approving, storing, control and distribution.

- CAF standard N-05.02-BZ-03 defines project documentation codification

Please note that software documentation from Supplier will comply with Supplier's documentation standardization. CAF approach for them is to have a document (as front page) following CAF procedures (format, people responsible at CAF of document, etc.) and then Supplier's document(s) referenced as annex in that document.

Please note also that CAF procedures include the option that models are adequate to Customer requirements (additional front page with Customer format, etc.).

4.1. LIST OF DOCUMENTS

Train level

Next table shows the list of documents per phase basis. What it is included is the code that will identify the document univocally along the project. These codes are the ones used to store documentation at CAF engineering data base (hereinafter BDI), as defined at CAF Codification Standard ([Ref.15]).

CAF Codification Standard considers up to 5 groups with this format:

L.	nn.	nn.	nnn.	nn
1er Grupo	2º Grupo	3er Grupo	4º Grupo	5º Grupo

Please note that in this table when only the first four groups are identified, it means the whole set of documents of fifth group (usually treated as annexes to the parent 00 document).

NAME	CODE
Planning	
Train Software Quality Assurance Plan	X.XX.98.001
Specification	
Requirements	*BERDE*
Train Design Review Report	*BERDE*
Architecture and Design	
Train Functional Descriptions	X.XX.75.9nn
Systems Technical Descriptions	X.XX.94.3EE.0S
Communications Interfaces Specification	X.XX.98.108.n0
(System) Communication Interfaces Specification cbc	X.XX.94.7EE.0S
HMI Specification	X.XX.98.101
Development	
Buses Frames/Ports definition documents	X.XX.98.108.nn
Integration	
Communications integration verification test protocols	X.XX.92.162.nn
Communications integration verification test reports	
Validation	
(TRAIN) type test protocols created and reviewed	X.XX.92.nnn.nn
(System) type test protocols created and reviewed	
(System) Software Configuration List	X.XX.98.3EE.0S
Installation / Setting into Operation	
Operator User Manuals	X.XX.97.400.00

Table 8: List of documents non safety related

NAME	CODE
Specification	
Safety Functions (SIL) Definition	X.XX.96.905
Architecture and Design	
Architecture SIL Apportionment	X.XX.96.906
Validation	
Hazard Log	X.XX.96.903
Safety Cases	X.XX.96.999

Table 9: List of documents safety related

Subsystem level

A detailed list of documents per Subsystem basis must be fully included or referenced at Subsystem Software Quality Assurance Plan (see [Ref.31] for sub-suppliers and [Ref.32] for CAF's PLC.

Please note that in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

On the other hand, if at project it is applicable IEEE standardization, then the Subsystem must comply with IEEE Std. 1558™-2004 standard applicable type (i.e. type 3 for PTE and BTEs' software and type 4 for the rest).

If these standards are not applicable to the subsystems then Supplier must comply with another recognized standard as ISO 9000-3 or with CAF standard procedures defined at "Software Quality Assurance (SQAP) included in EEFAE's" (see [Ref.10]), which recommends Supplier to provide to CAF these documents:

- Software Quality Assurance Plan (SQAP)
- Software Development Plan (SDP) with the planning of all new and/or modified SW. Please note that SW can be considered as no modified only if what changes is parametrization, that is, no change of source code, no change on parameters' structure and no change to its data base structure.
- Software Configuration Management Plan (SCMP)
- Software Verification and Validation Plan (SVVP)
- Software Requirements Specification (SRS)
- Software Design Description (SDD)
- Software Verification and Validation Report (SVVR)
- Software Version Description (SVD) or Release Note (RN)
- Software User Manual

Selected approach and standardization compliance must be defined at Subsystem SQAP along with the sets of documents.

4.2. DOCUMENTS DESCRIPTION

Train level

Next table shows a brief description of every document.

Phase	Output Doc.	Document Description
Plan	Train SQAP	Document with train project quality assurance approach, including management issues, phases and tasks, standardization, metrics, etc.
Develop.	Train Requirements	Train Requirements are included at Requirements Data Base (BERDE)
	Train Design Review Report	Conclusions of Design Review are included at Requirements Data Base (BERDE)
Architect. Design	Train Functional Descriptions	Description of functionalities at train (high) level, so that they can be understood and reviewed with final Customer. They include the assignment of functionalities and / or sub functionalities by system basis.
	Systems Technical Desc.	Description of functionalities to be performed by the System, including how (hardware, software, etc.)
	CIS	Communications Interface Specification document includes the comm. protocol for the different shared buses (as MVB, RS485, etc.) and also the common functionalities applicable to all systems (as time stamp)
	HMI Spec.	Human Machine Interface Specification document includes the description of drivers and maintenance screens in a high user level
Integra.	Comm. Protocol	Document with the tests to be done to check that communication through a shared bus is correct.
	Comm. Report	Records of corresponding protocols
Validation	Type Protocols	Document with the tests to be done to check that functionality in the train is correct.
	Type Reports	Records of corresponding protocols
	Software Configuration List	Document model [Ref.12] with the validated system software versions. Please note that this document includes only software considered as application or configuration software, and not firmware
Operation	Train Users Manuals	Manuals with the information necessary to drive the train and also to perform its maintenance in an appropriate way.

Table 10: Not safety related Documents' Description

Phase	Output Doc.	Document Description
Specification	Safety Functions (SIL) Definition	Identification of SIL functionalities
Architect. Design	Architecture SIL Apportionment	Document in which the safety responsibilities of the different subsystems/components is allocated at architecture level
Val.	Hazard Log	Document in which all the hazards of the project are followed-up, including their mitigation measures.
Operation	Train Users Manuals	For safety issues they will include the Safety Related Applications Conditions

Table 11: Safety related *D*ocuments' Description

Subsystem level

Description of documents per Subsystem basis must be fully included or referenced at Subsystem Software Quality Assurance Plan (see [Ref.31] for sub-suppliers and [Ref.32] for CAF's PLC.

Please note that as before, in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

And if at project it is applicable IEEE standardization, then the Subsystem must comply with IEEE Std. 1558^{TM}-2004 standard

If not, then Supplier must comply with another recognized standard as ISO 9000-3 or with CAF standard procedures defined at "Software Quality Assurance (SQAP) included in EEFAE's" (see [Ref.10]).

5. STANDARDS, PRACTICES, CONVENTIONS AND METRICS

5.1. PURPOSE

This section must be included at every SQAP. It shall:

a) Identify the standards (mandatory requirements), practices (recommended approach), conventions (accepted guidelines), and metrics (system of measurement) to be employed by all associated with the project, including management and vendors. It will specify the phases of the life cycle to which they apply.

b) State how compliance with these items is to be monitored and assured.

5.2. CONTENT

The subjects covered will include the basic technical, design, and programming activities involved, such as documentation, variable and module naming, programming, inspection, and testing. The following information will be provided:

(1) Documentation standards
(2) Logic structure standards
(3) Coding standards
(4) Commentary standards
(5) Testing standards and practices
(6) Selected software quality assurance product and process metrics such as:
- (a) Branch metric
- (b) Decision point metric
- (c) Domain metric
- (d) Error message metric
- (e) Requirements demonstration metric.

Please note that as before, in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

If not, then Supplier must comply with another recognized standard as ISO 9000-3 or IEEE Std 1558™-2004.

Please note that for Train level the outputs are only documentation, no software. This documentation is based on international standards (as EN50128, IEEE and ISO) and in CAF internal procedures and models (certified ISO and IRIS), and their compliance is assured by CAF releasing procedures that include reviewing and releasing done by different responsible.

6. REVIEWS AND AUDITS

6.1. PURPOSE

The software produced or modified for the project and their associated documentation will be reviewed on a planned basis to determine the extent of progress and to evaluate the technical adequacy of the work and its conformance to software requirements and standards.

Technical reviews will be conducted to evaluate the status and quality of the software development effort.

The examination of project issues (both technical and managerial) will be done at various phases during the project life cycle.

The results of such examinations are meant to permit improvement of the methods of ensuring software quality and the ability to meet time and cost constraints.

6.2. REQUIREMENTS

<u>**Train Level**</u>

Reviews by phase basis are defined herein:

- Planning review:

  Revision of SQAP is done as part of document release process.

  Moreover, at the end of every phase it will be reviewed if the SQAP needs to be updated (as defined at section 16)

  Please note that as Train SQAP includes also the Train Software Configuration Management approach, that is, Train SCMP, and Train Software Verification and Validation approach, that is, Train SVVP, then this review covers the purpose of following reviews defined by IEEE730-2002 [Ref.5] [Section 4.6]:

  - Verification and validation plan review
  - Software configuration plan review

- Specification and Design review:

  Its purpose is to verify that all requirements have been included at BERDE, that they are complete, understandable and testable, and that they have been already assigned.

  It will be performed by Technical Project Manager and their results recorded at what has been called Train Design Review Report.

  This review covers the purpose of following reviews defined by IEEE730-2002 [Ref.5] [Section 4.6]:

  - Software specifications review (SSR)
  - Architecture design review (ADR)

    - Detailed design review (DDR)

- Train SW release meeting:

  The purpose of this meeting is to verify the software has been correctly validated before establishing a train base-line, that is, that all type tests protocols have been passed with a satisfactory result.

  Applicable documentation and versions will be checked and the train base-line created as output to this meeting.

  It covers the purpose of following reviews and audits defined by IEEE730-2002 [Ref.5] [Section 4.6]:

    - Functional audit
    - Physical audit
    - Post-implementation review

- In-process reviews: will be applicable to train documents to check that they are updated accordingly to train design, and to train software base-line.

- Managerial reviews: The project manager organizes periodic project meetings where managerial aspects are reported.

Other reviews and audits are not applicable for CAF within is train integrator role.

<u>Subsystem Level</u>

Description of reviewing approach per Subsystem basis must be fully included or referenced at Subsystem Software Quality Assurance Plan (see [Ref.31] for sub-suppliers and [Ref.32] for CAF's PLC) or Software Verification and Validation Plan (SVVP).

Please note that in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

In case IEEE standardization applicable, then reviews must be held according to IEEE730-2002 [Ref.5] standard.

Anyway, Supplier must define in his SQAP (or SVVP) the review approach, which must be approved by CAF.

Apart from Supplier internal review process, CAF System Managers will review system software documentation and maintain periodical design reviews with Suppliers (minimum a preliminary design review and a final design review).

Please note that reviews and audits are applicable only to the software configuration items defined as new or modified.

7. TEST

Train Level

Testing at train basis are those applicable to systems' integration and to validation at real target.

Their definition is included in the following sub-sections which constitutes Train Software Verification and Validation approach that is Train SVVP.

Subsystem Level

Test procedures at subsystem basis will be defined at Software Verification and Validation Plan (SVVP) prepared by each Supplier.

It will identify and describe the methods, approaches, and techniques to be used (or reference appropriate test documentation that has been developed for the project), and the test planning

The testing process should adequately address the preparation and review of documentation associated with the testing process, including test plans, test design and test case specifications, test procedures and test instructions, test schedule, test reports, and test incidents and their resolution.

The evaluation of the results of testing will be described at Supplier Software Verification and validation Report (SVVR).

Please note that in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

In case IEEE standardization applicable then Supplier must comply with them.

7.1. TRAIN SOFTWARE VERIFICATION AND VALIDATION

If a functionality, identified as safety has a software involved, then its verification and validation procedures must comply with what is stated at standard EN50128 [Ref.3], according to the SIL level identified for that function. If SIL level is higher than 0, this will imply to obtain a SIL assessed by an external independent safety assessor.

Verification and Validation approach is briefly explained here:

1. CAF as train integrator will sub-divide general requirements into sub-requirements that will be allocated into sub-systems.

2. Those sub-systems that have any requirement with SIL>0 will have to obtain the appropriate EN50128 certificate or assessment by an accredited independent safety assessor. Please note that this applies not only to external Suppliers but also to CAF internally developed software, that is, the Train Programmable Logic Controller (PLC) developed at CAF Technical Office Systems Area.

3. Those sub-systems, provided by an external Supplier, without SIL assigned or with SIL = 0, will have to demonstrate to CAF Quality Department the adequacy of its software quality procedures including its internal process of software verification and validation. Please note that CAF will reserve the right of asking for any software documentation, as Software Verification and Validation Plan (SVVP), Software Test Plan (STP), etc., of assisting to any internal verification and validation procedures, of performing any audit to Supplier's facilities, and of asking for special tests to be done under CAF request (type tests at origin).

4. For CAF PLC, if it doesn't have any SIL>0 requirement allocated, then it will comply with Systems Area Guidelines, which are based on EN50128 standard.

5. Once all the sub-systems have been validated by their own (by following the afore mentioned process), CAF as train integration will perform the functional integration verification and validation process in this way:

    a. Communication Integration Verification: based on checking the common interface understanding and use of communication buses that are shared between sub-systems (as MVB, RS485 and son on) is checked in a bench tester.

    b. Validation: tests at real target (the train) are done, either at CAF facilities (factory type tests) and/or at track (track type tests) when functionality to be tested depend on train movement or track infrastructure.

Further description of this CAF train integration Verification and Validation Process is included at next sections.

7.1.1. Communication Integration Verification

Its objective is to test the integration of all train systems over the shared buses.

It will be done a test for every train system that shares a train bus that will consist in checking the good quality of communications and the correct interpretation of variables interchanged between train systems. It will be verified that a system uses appropriately the train bus(es) and that it sends/receives what it has been defined at Communication Interface Specification (CIS) document, which is part of CAF train integration tasks.

7.1.1.1. Definition of Test Protocols

Purpose: To define the tests to verify that communications implementation has been correctly done, that is, all port (or frames) and variables are sent at the position, timing, etc. that has been defined, so that data interchanging between systems is correct.

Input: Communications interface specification (CIS) document(s) ([Ref.40]).

Output: (Bus) Communication Integration Test Protocol ([Ref.43]).
Note: there will be an independent document for every shared train bus type.

Phase explanation:

Test protocol for every kind of buses is written by TCMS Supplier based on what it has been defined at the corresponding bus CIS document.

So, previously a CIS document must be written by CAF TCMS System Manager, because although it is the TCMS Supplier who establishes the bus characteristics attending to its hardware platform, the TCMS System Manager will define:

a) the final bus interface characteristics, i.e. in case different options for any bus OSI layer, he or she will choose and agree definitive characteristics with TCMS Supplier, and

b) common integration criteria, as protection against communication failures, techniques for validating received data, events log synchronization, software control version, and so on

Test protocol will be reviewed before its approval and distribution by TCMS System Manager in order to check that all aspects have been considered and tests are enough and appropriate.

TCMS System Manager will also check that bench tester proposal and implementation is correct, that is, all TCMS platform devices necessary to perform communication integration tests have been considered and included in the platform, and their configuration correctly done.

7.1.1.2. Execution of Tests

Purpose: To perform communications integration tests with every system connected to train shared buses, for every kind of bus

Input: (Bus) Communication Integration Test Protocol ([Ref.43]).

Output: (Bus) Communication Integration Verification Report ([Ref.43]).

Phase explanation:

Tests will be done by using real TCMS hardware and, when possible, System real hardware.

Test protocol defines the procedures to check the correct use of the shared bus by the System's Supplier and CAF's PLC and the correct implementation of the data interchanging between them through the bus.

TCMS Supplier will be the responsible of generating the verification test report(s) whereas the CAF TCMS Manger will verify that test reports demonstrate that communication integration has been reached.

7.1.2. Train Validation

7.1.2.1. Definition of Validation Test Protocols

Purpose: To define the set of protocols that is necessary for Train Validation.

Inputs: System technical description; in which system functionality has been defined ([Ref.42])
Train functional description(s); where train schematic dependent functionalities are defined ([Ref.38])

Output: System and Train factory / track type test protocols ([Ref.43])

Phase explanation:

Every System Supplier will define the type tests that must be performed at train (factory and track) in order to validate his/her system's functionality.

The corresponding CAF System Manger will verify that the proposed protocols are correct by reviewing a) that all system's functionalities have been considered, and b) that proposed tests are enough to check its requirements (considering all the possible train casuistic).

Meanwhile, the person responsible of train functionality will write the train factory / track protocols, considering all the functionalities defined in Train functional descriptions.

Person responsible of approving all train type test protocols is Project Technical Manager.

7.1.2.2. Execution of Validating Test Protocols

Purpose: To perform type test protocols

Input: All factory / track type test protocols

Output: Factory / track type test results

Phase explanation:

Validation tests will be performed by CAF Test Department, who will generate validation test reports.

Verification of this phase will be performed by CAF Quality department (for non-safety related functions) or by CAF Safety department (for safety related functions) who will check that all tests protocols have been performed and test results have been correct.

8. PROBLEM REPORTING AND CORRECTIVE ACTION

Problems encountered during software development or operation may result from defects in the software, supporting and development processes, hardware, or operations. Because of their diversity, the determination of the sources of a problem and the appropriate corrective action requires a centrally controlled system for monitoring problems and determining root causes.

The purposes of problem reporting and corrective action systems are to:

a) Assure that problems are documented, corrected, and used for process improvement.

b) Assure that problem reports are assessed for their validity.

c) Assure reported problems and their associated corrective actions are implemented in accordance with customer approved solutions.

d) Provide feedback of problem status to the developer and the user.

e) Provide data for measuring and predicting software quality and reliability.

Software Configuration Management (SCM) usually implements the problem reporting and corrective action system. For this purpose, CAF has a rightly defined and used Configuration and Changes Process as defined herein (see Train level section) and within CAF standard procedure (see [Ref.11]).

The main goal of SCM process is to maintain a proper control of the identification and version of all the software modules contained within the systems along the whole project: design, manufacturing and warranty period

Please note that this section constitutes Train Software Configuration Management Plan, so that no other specific document is done.

Train Level

The procedures for problem reporting and corrective actions are handled according to the quality management procedures defined at CAF, in this way:

- When a non-conforming issue is detected by System Manager related to a System Documentation, it will appear in the corresponding verification report, which will include also the corrective actions to be done along with their planning.

- If a problem or discrepancy is detected during validation process, then:
    - CAF Test Department will create an incidence, including a description of the problem, the person who has detected it, date and (UT) location, related tests and so on.
    - This incidence is transferred to the corresponding CAF System Manager, or in case it involves more than a System to the Systems Area Coordinator.
    - Once the System responsible of the bug is identified, its System Manger will start a Modification Request document (model [Ref.13]), that he or she will send to System Supplier
    - System Supplier will study and analyze the problem and look for a solution. The analysis and its proposed solution is incorporated to the modification request, and sent to System Manager

- o If System Manager agrees then he or she will sign the Modification Request and send it to Test Department, so that modification can be validated at train. Please note that a software version can be upload in a train only if this Modification Request is already signed by the System Manager
- o Test Department will perform the test again and report if proposed solution works or not
- o If correct, then new software version is approved by the System Manger and a new official System software release done (system base – line updated).

Sometimes it is necessary to create a Software version that will be used only for a short time, or only for some units, or to perform a specific test that needs the software to simulate some environment conditions.

In this case software versions will not be official but concessions, and the way to manage them is by using a Request for Modification, including the characteristic “concession” at the “Modification Approval”. The approval of this software version will not imply a new edition of Configuration List (updating of base-line).

Subsystem Level

System SQAP must include methods to be used to assure the reported problems are being properly addressed. The SQAP will describe the organizational element(s), provisions, and timely procedures for documenting, validating, tracking, and reporting the status of problems and the appropriate corrective action.

Validating, tracking, and resolving problems require the coordination of various groups within the organization of each supplier. The SQAP will specify the groups responsible for authorizing and implementing problem reporting and corrective actions, and submission of unresolved issues to management for resolution.

Please note that in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

In case IEEE standardization applicable then Supplier must comply with them.

Please note that EN50128 and IEEE applies for Supplier internal SMC procedures don’t exempt him of complying with CAF standard procedure (see [Ref.11]), which states documentation configuration identification format to be given to CAF by systems basis, that is Configuration List model [Ref.12], and the procedures for software version incidences report and change control, that is, Request for Modification model [Ref.13] and procedure defined at Train Level paragraphs.

9. SQA TOOLS, TECHNIQUES, AND METHODOLOGIES

Train Level

Tools used for CAF Train SQA processes are Microsoft office (documentation), DOORS (requirements management) and ENOVIA (media control)

Techniques and Methodologies are defined at CAF standard procedures, which have been certified by ISO 9001 and IRIS

Subsystem Level

This section of the SQAP prepared by each supplier will identify the special software tools, techniques, and methodologies that support SQA, state their purposes, and describe their use.

It will list or reference those tools, techniques, and methodologies that are available, and those that need to be acquired or developed.

SQA software tools aid in the evaluation or improvement of software quality. Typical tools include, but are not limited to, operating system utilities, debugging aids, documentation aids, structuring preprocessors, structure analyzers, code analyzers, standards auditors, simulators, execution analyzers, performance monitors, statistical analysis packages, software development folders/files, software traceability matrices, test drivers, test case generators, static or dynamic test tools…

SQA techniques are technical and managerial procedures that aid in the evaluation and improvement of software quality. Such techniques include review of the use of standards, software inspections, requirements tracing, requirements and design verification, reliability measurements and assessments, and rigorous or formal logic analysis.

SQA methodologies are integrated sets of the above tools and techniques.

Please note that in case software has assigned any Safety Integrity Level higher than 0 according to EN5012x standard, then it must fully comply with what is defined at EN50128 standard [Ref.3] for that level.

10. MEDIA CONTROL

Train Level

Control of official versions for documentation is done through CAF Technical Office engineering database (BDI) supported by ENOVIA.

Subsystem Level

This section of the System SQAP shall state methods and facilities to be used to:

a) Identify the media for each computer product and the documentation required to store the media, including the copy and restore process.

b) Protect computer program physical media from unauthorized access or inadvertent damage or degradation during all phases of the software life cycle. This may be provided as a part of the SCMP. If so, an appropriate reference will be made thereto.

Computer program media can be defined as those media on whom computer data are stored.

The media control methods and facilities will ensure that:

a) The software is stored and retrieval is assured.

b) Off-site storage and retrieval are provided for critical software and copies of baseline code.

c) The software is accessible only to those with the need of access.

d) The environment is controlled so that the physical media on whom the software is stored does not degrade.

e) A description is provided of how compliance with the above is assured.

11. SUPPLIERS CONTROL

Depending on the level of development required for the project, software will be classified as:

a) Previously developed software: The Supplier must ensure the suitability of the product for use with the software considered as previously developed. For that, a gap analysis must be done reaching, as a minimum, the following levels:

- Requirement level analysis: indicating which requirements are different (if any) from previous projects where software under analysis is implemented.
- Environment level analysis: indicating which interfacing items are different (if any) from previous projects where software under analysis is implement (other software modules, hardware platform where software runs etc.)

b) New Software: It includes software that doesn't exist previously or software that needs modifications for the project that suppose a change on codification or a change of data bases or configuration files formats. For this software, Suppliers will be required to comply with the requirements of this SQAP. The SQAP produced by each supplier shall be subject to approval by CAF.

12. SQA RECORDS, COLLECTION, MAINTENANCE AND RETENTION

Train Level

All the work is done in electronic form and stored on CAF servers as it has been explained at section 10 of present document

Subsystem Level

Suppliers will include in their corresponding System SQAP, at this section, the SQA documentation to be retained, the methods and facilities to be used to assemble, safeguard, and maintain this documentation, and will designate the retention period.

13. TRAINING

Train Level

CAF quality management system (ISO and IRIS) guarantees that education of employees is in accordance with their responsibilities.

Subsystem Level

Suppliers will detail in their SQAP their approach for this section.

14. RISK MANAGEMENT

The project risks are identified during project planning by CAF Safety department and those related to Systems will be exported to them and controlled by CAF System Manager to minimize the resulting consequences to software activities.

The primary aim of risk management is to ensure and demonstrate that all risks have been reduced to a level that is broadly acceptable or tolerable. Risk management comprises the activities of risk analysis, risk evaluation risk reduction and risk acceptance.

All information about risk management is included at project Safety Plan (see reference [Ref.22]).

15. GLOSARY

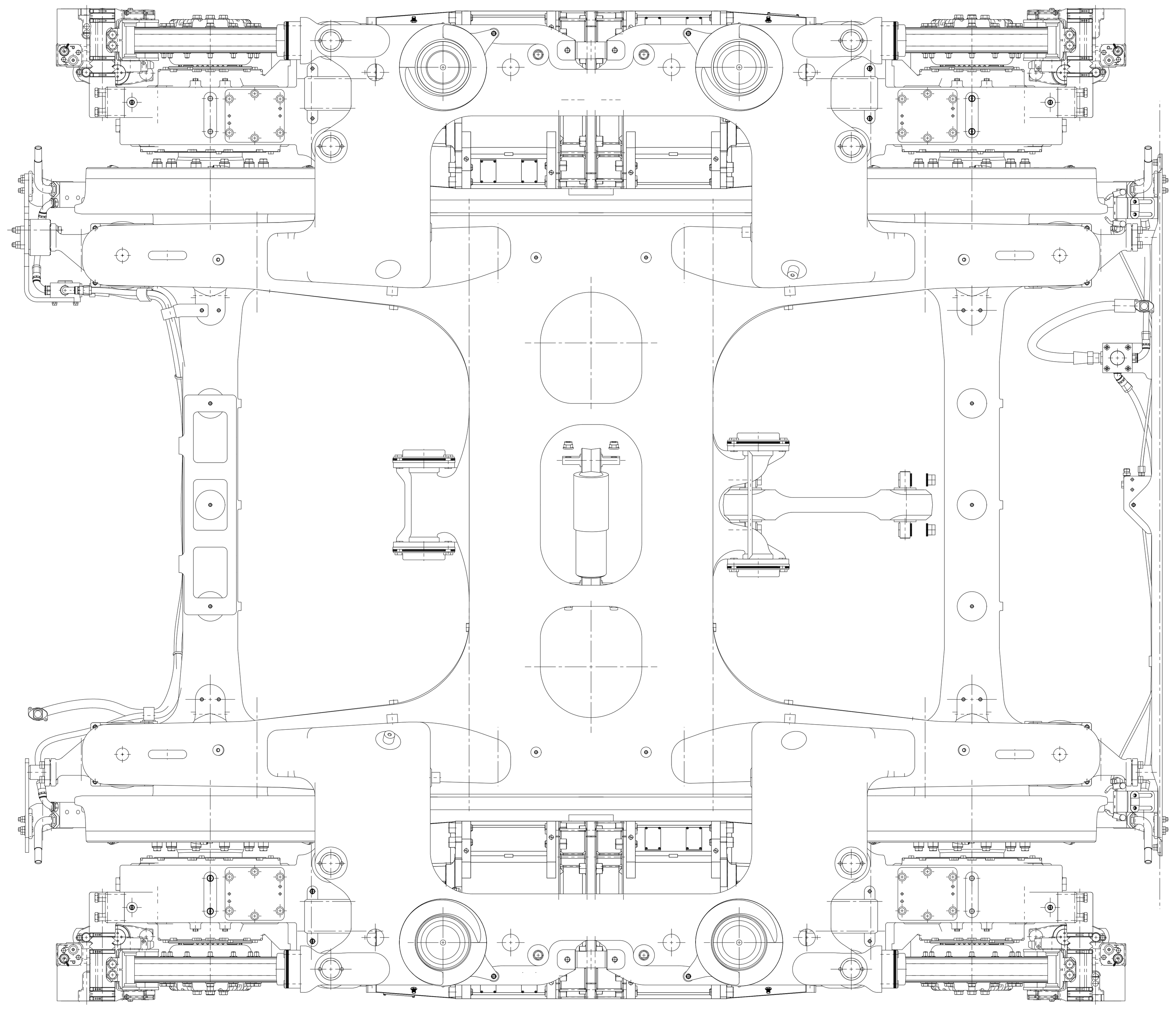
Abb.	Description
BDI	Engineering Data Base
BERDE	Requirements Data Base
CAF	Construcciones y Auxiliar de Ferrocarriles
CIS	Communication Interface Specification
DBDD	Database Design Description
EFAE	Fundamental external stock element
HMI	Human Machine Interface
ICD	Interface Control Document
IRIS	International Railway Industry Standard
PLC	Train programmable logic controller
RN	Release Note
SCI	Software Configuration Item
SCMP	Software Configuration Management Plan
SDD	Software Design Description
SVD	Software Version Description
SIL	Safety Integrity Level
SQA	Software Quality Assurance
SQAP	Software Quality Assurance Plan
SRAC	Safety Related Application Conditions
SRS	Software Requirements Specification
SRTM	Software Requirements Traceability Matrix
STP	Software Test Plan
STR	Software Test Report
SVVP	Software Verification and Validation Plan
SVVR	Software Verification and Validation Report
TCMS	Train Control and Monitoring System

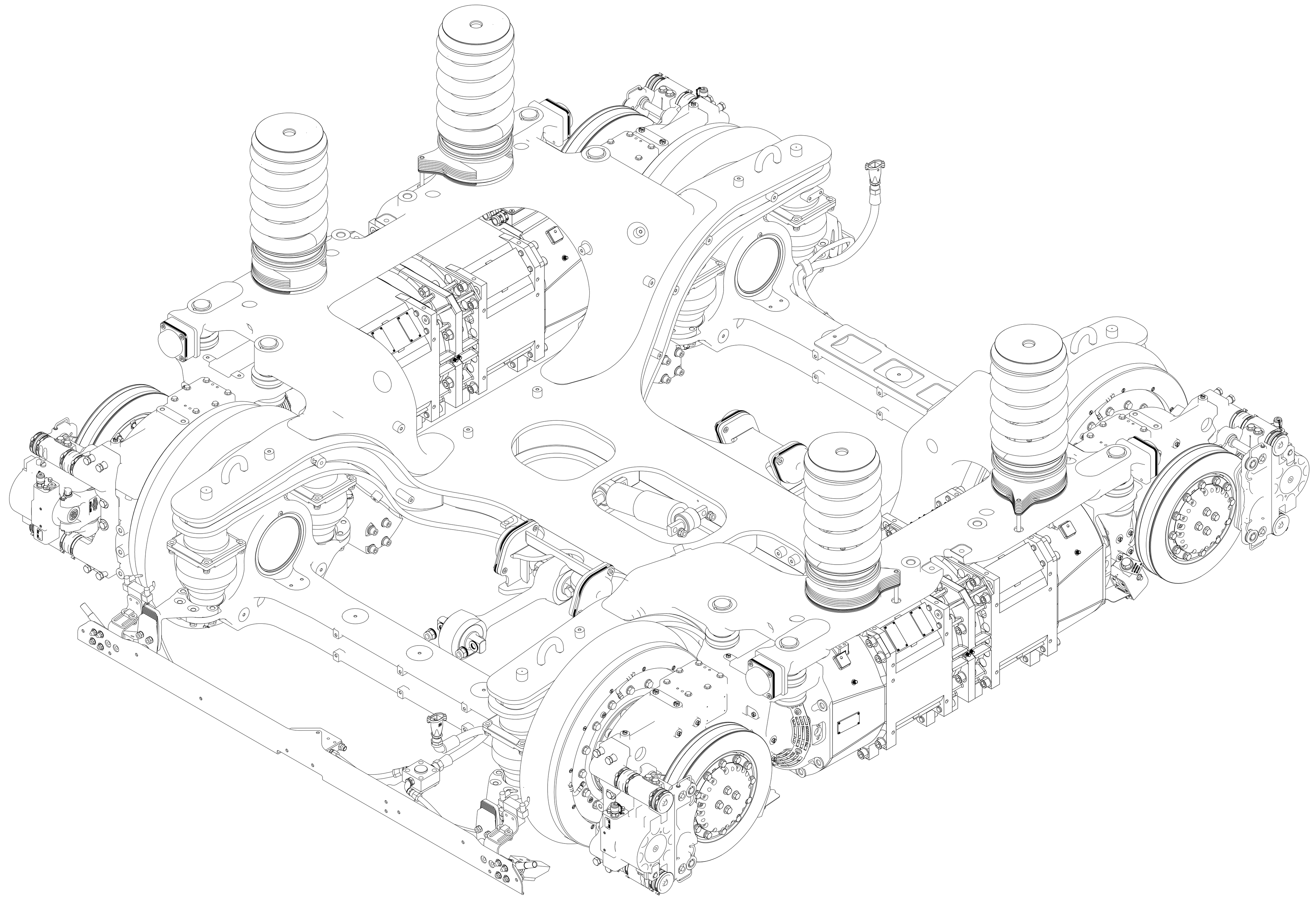
Table 12: *Abbreviations*

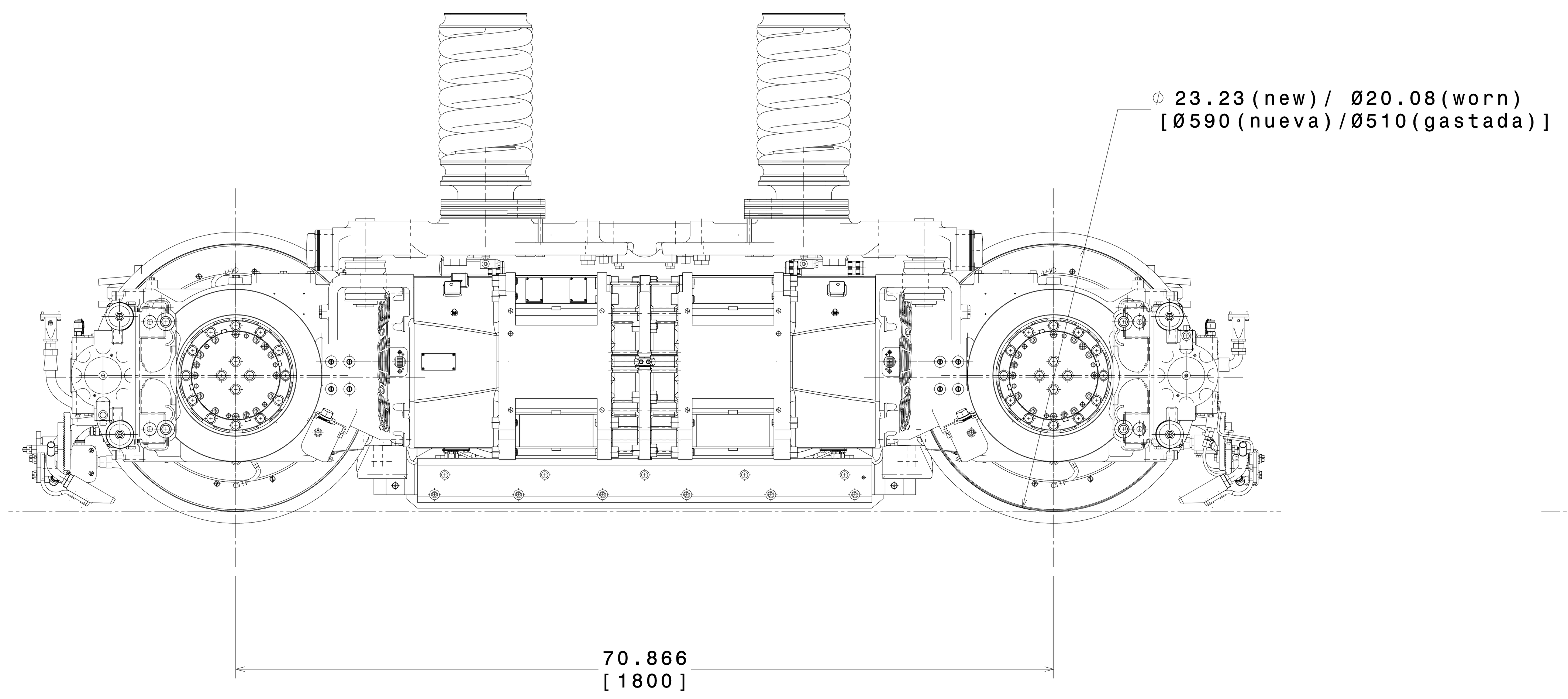
16. SQAP CHANGE PROCEDURE AND HISTORY

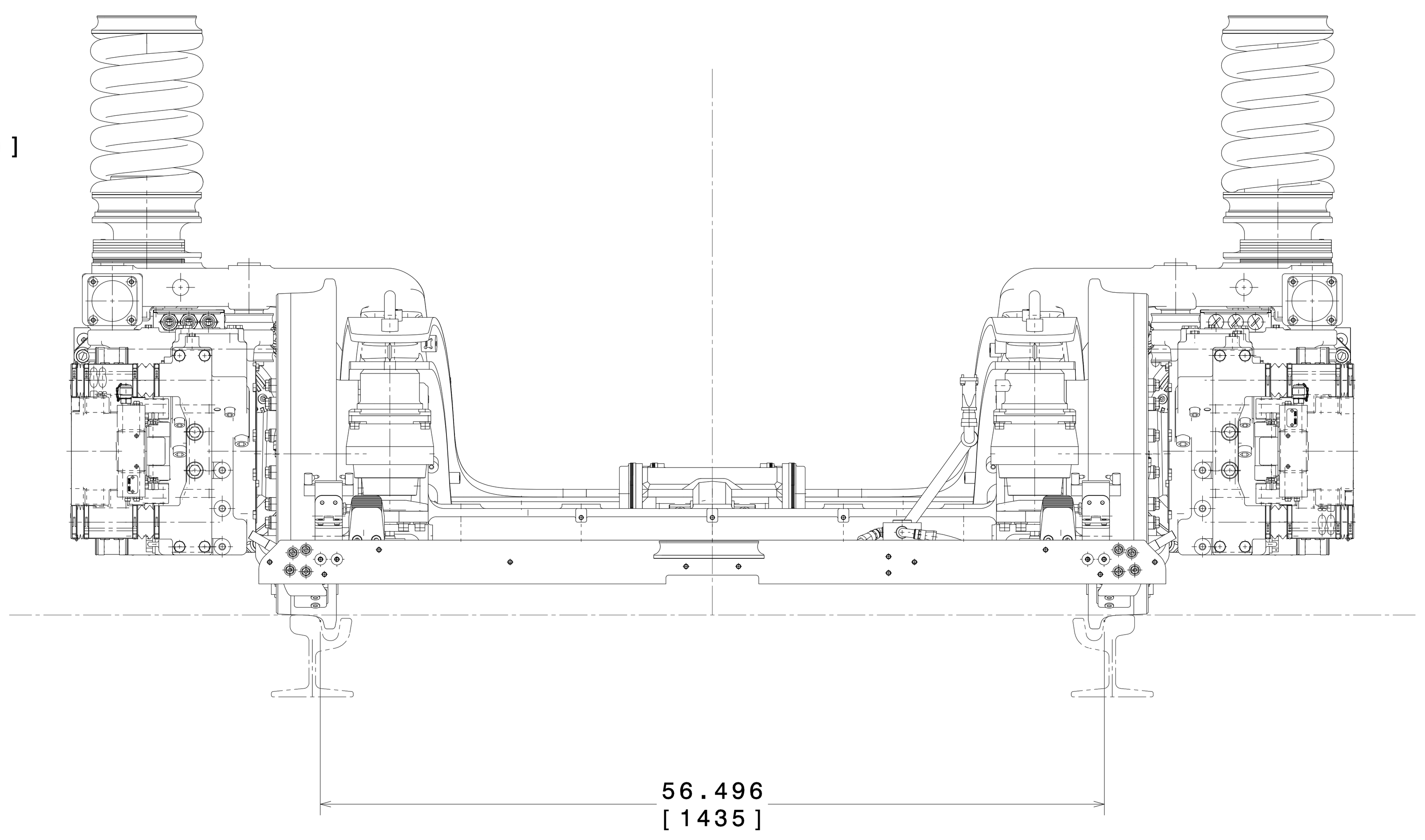
The Edition Control must be fulfilled with the current edition number, the released date and a detailed description of all changes from the previous release of the SQAP.

Updating will be made by the owner of the document and reviewed by its verifier.









MODIFICACIONES

	FECHA	NOMBRES
COMPR.		
VERIFIC.		
HOMOL.		

PLANO N°

SUSTITUYE A:

EDICION

TOL.GEN	ESCALA
ISO 2768-cK	1/20

DESIGNACION:

MOTOR BOGIE

HOJA N° 1

N° DE HOJAS 1

APLICACIONES

	FECHA	NOMBRES
DIBUJ.	28-02-2017	M.LARRAÑAGA
VERIFIC.	28-02-2017	A.OTERMIN

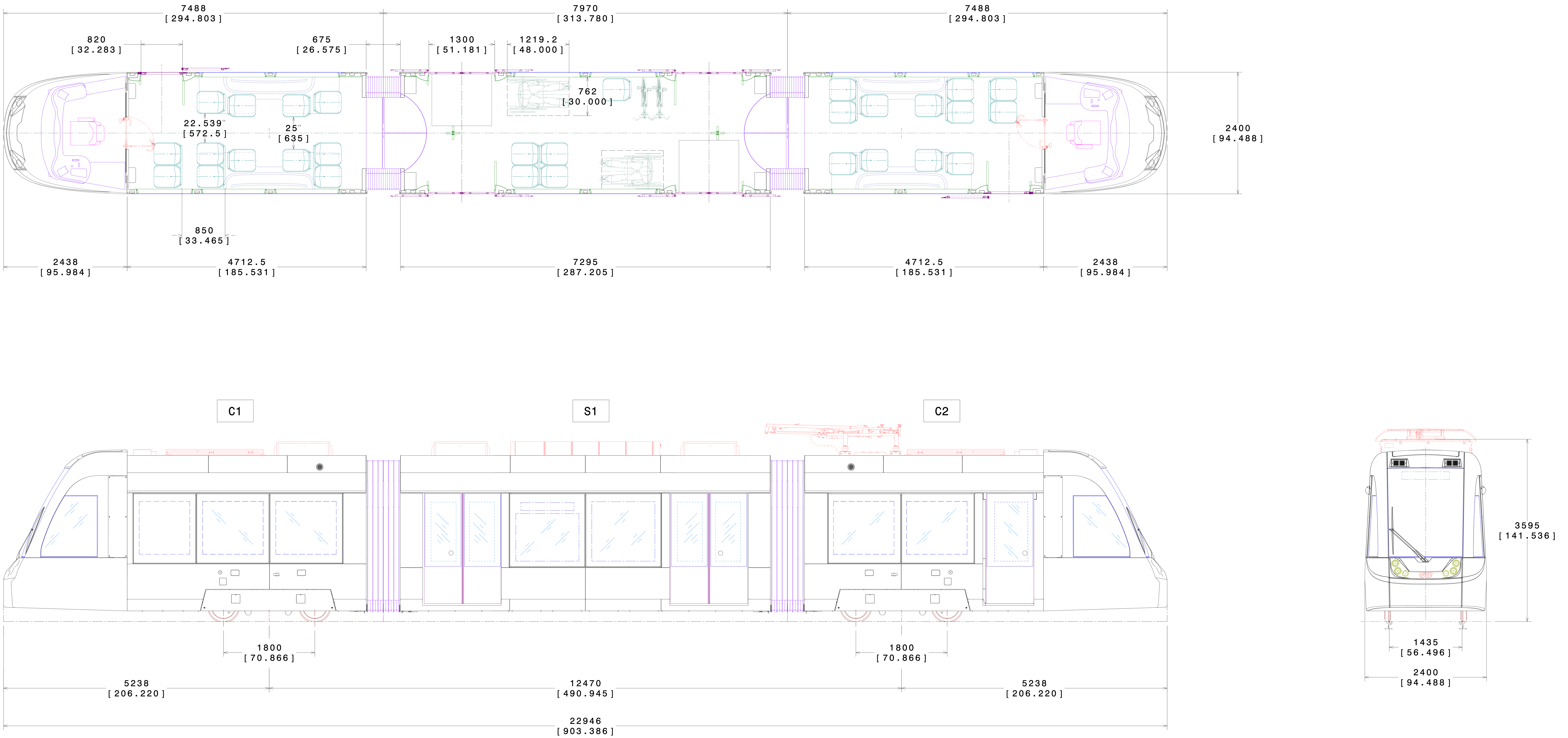
ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)

REFERENCIA: L.00.860.00.000

-FIRST HILL STREETCAR-

SUSTITUYE A :

EDICION



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	COMPR.			PLANO Nº
	VERIFIC.			
	HOMOL.			
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	TOL.GEN ISO 2768-cK	ESCALA 1/40	DESIGNACION: GENERAL UNIT ASSEMBLY	HOJA Nº 1 / Nº DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.00.000
	VERIFIC.	28-02-2017	A.OTERMIN	
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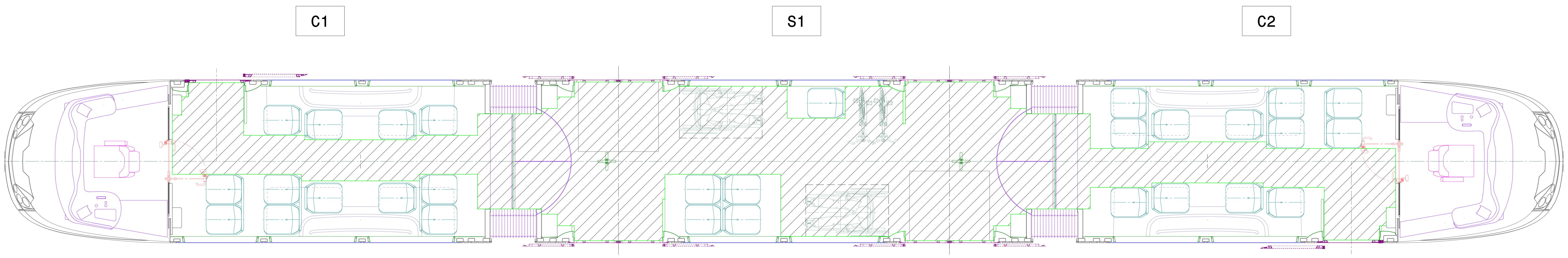
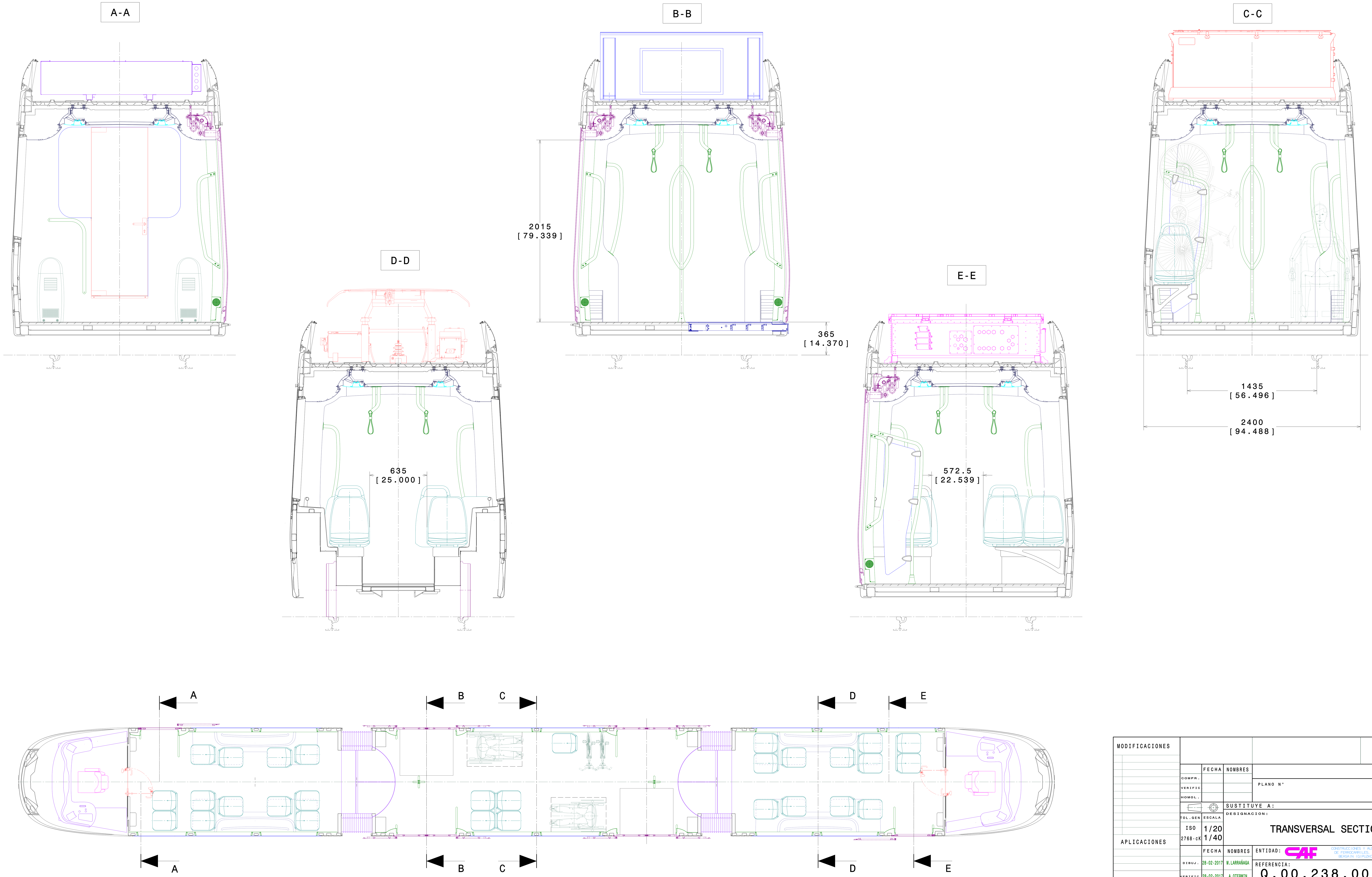


UNIT CAPACITY					
		C1	S1	C2	TOTAL
SEATS		12	5	12	29
AREA m^2		4.102	14.774	4.102	22.978
STANDEES	$4p/m^2$	16	59	16	91
	$6p/m^2$	24	88	24	136
SEATED + STANDEED	$4p/m^2$	28	64	28	120
	$6p/m^2$	36	93	36	165

MODIFICACIONES	FECHA	NOMBRES	PLANO Nº	
	COMPR.			
	VERIFIC.			
	HOMOL.			
			SUSTITUYE A:	EDICION
	TOL.GEN ISO 2768-cK	ESCALA 1/40	DESIGNACION: CAPACITY	HOJA Nº 1 / Nº DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.00.020
	VERIFIC.	28-02-2017	A.OTERMIN	
-FIRST HILL STREETCAR-	SUSTITUYE A :			EDICION



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	VERIFIC.			
	HOMOL.			
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	TOL.GEN. ISO 2768-cK	ESCALA 1/20 1/40	DESIGNACION: TRANSVERSAL SECTIONS	HOJA Nº 1 / Nº DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.00.030
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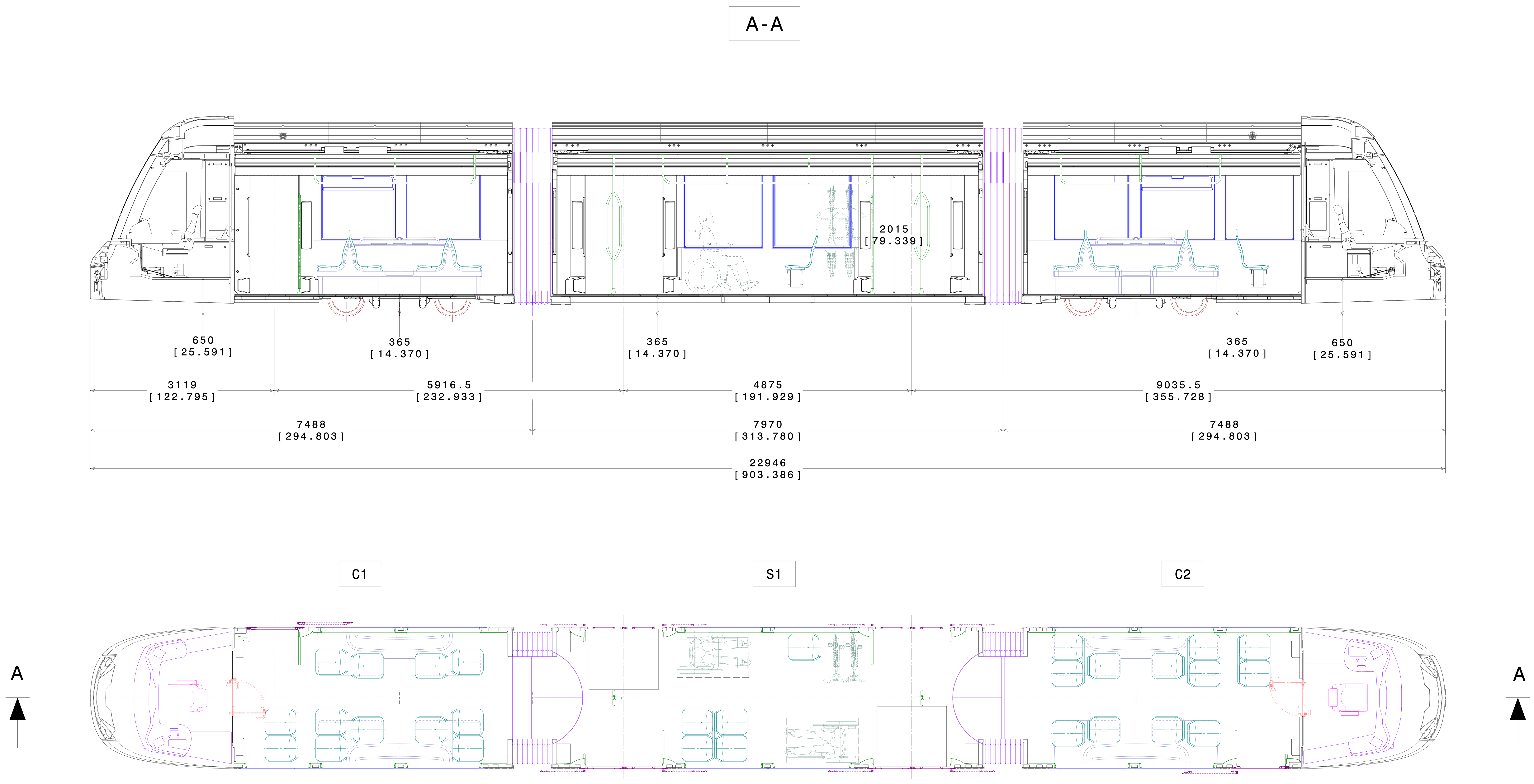
-FIRST HILL STREETCAR-	SUSTITUYE A :			EDICION



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COMPR.			
VERIFIC.			
HOMOL.			
		SUSTITUYE A:	EDICION
TOL.GEN. ISO 2768-cK	ESCALA 1/40	DESIGNACION: LONGITUDINAL SECTION	HOJA Nº 1 / Nº DE HOJAS 1
APLICACIONES	FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.00.031
VERIFIC.	28-02-2017	A.OTERMIN	
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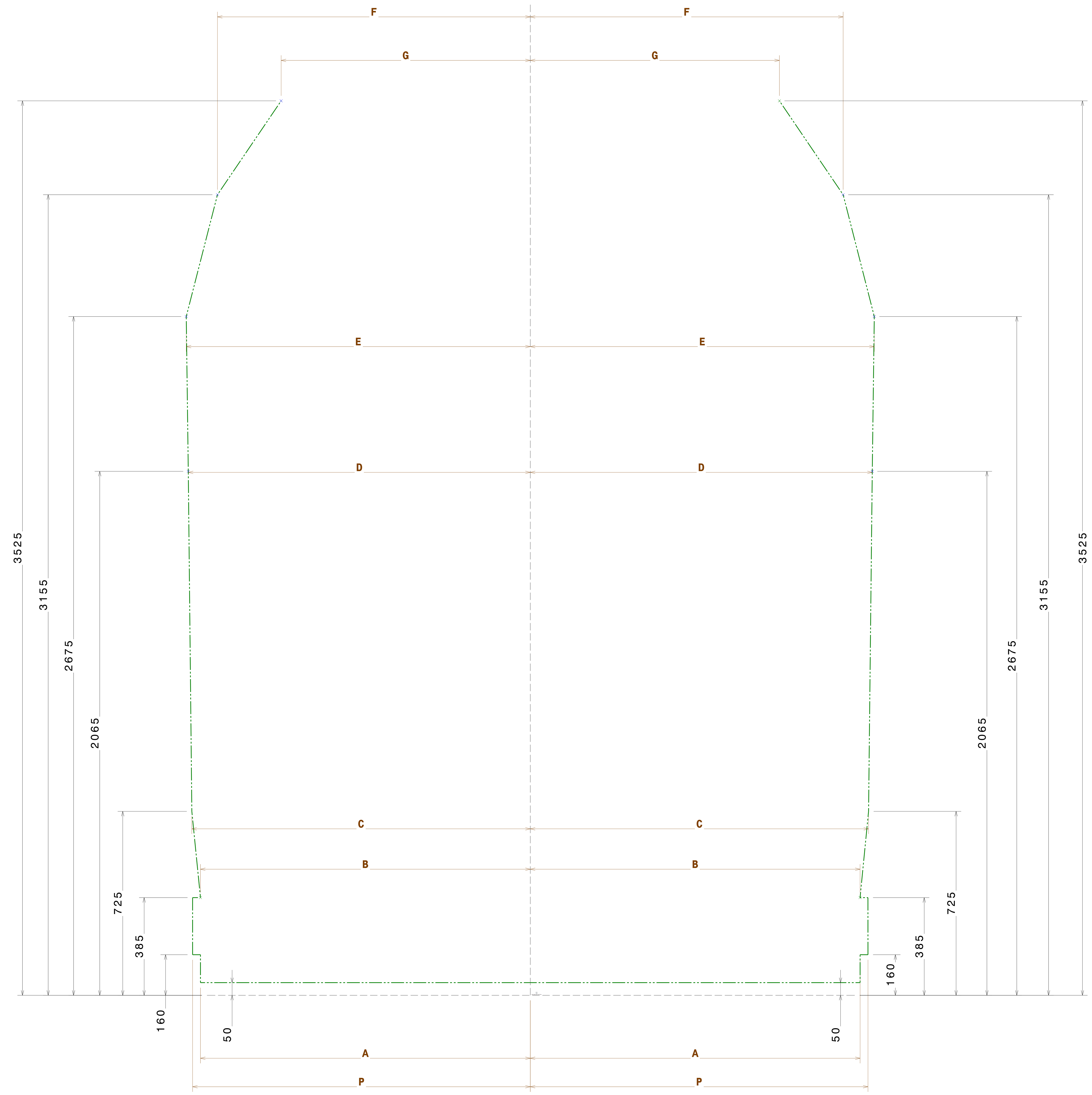

DYNAMIC ENVELOPE OUTER SIDE (mm)														
R	**20**	**25**	**30**	**40**	**50**	**70**	**90**	**100**	**200**	**300**	**500**	**1000**	**2000**	**ALIGN.**
A	1772	1656	1577	1478	1418	1397	1383	1378	1354	1347	1336	1327	1325	1315
B	1771	1655	1576	1477	1417	1396	1382	1377	1353	1346	1335	1326	1324	1313
P	1771	1655	1576	1477	1417	1396	1382	1377	1353	1346	1335	1326	1324	1313
C	1787	1670	1592	1493	1433	1411	1397	1392	1368	1362	1351	1341	1339	1329
D	1815	1699	1620	1521	1461	1440	1426	1421	1397	1390	1379	1370	1367	1357
E	1821	1704	1626	1527	1467	1446	1431	1426	1402	1396	1385	1375	1373	1363
F	1745	1628	1550	1451	1391	1369	1355	1350	1326	1320	1309	1299	1297	1287
G	1597	1480	1402	1303	1243	1222	1207	1202	1178	1172	1161	1151	1149	1139

DYNAMIC ENVELOPE INNER SIDE (mm)														
	20	**25**	**30**	**40**	**50**	**70**	**90**	**100**	**200**	**300**	**500**	**1000**	**2000**	**ALIGN.**
A	1569	1509	1470	1420	1391	1356	1335	1328	1319	1324	1322	1320	1321	1315
B	1573	1513	1473	1424	1395	1360	1339	1332	1318	1323	1321	1319	1320	1313
P	1623	1563	1523	1474	1445	1410	1389	1382	1347	1337	1324	1319	1320	1313
C	1609	1549	1509	1460	1431	1396	1375	1368	1333	1338	1337	1334	1336	1329
D	1585	1525	1485	1436	1407	1372	1351	1350	1362	1367	1365	1363	1364	1357
E	1571	1511	1472	1423	1393	1358	1353	1356	1367	1372	1371	1368	1370	1363
F	1556	1496	1456	1407	1378	1343	1322	1315	1291	1296	1295	1292	1294	1287
G	1453	1393	1354	1305	1275	1240	1219	1212	1178	1167	1155	1144	1146	1139

MODIFICACIONES

	FECHA	NOMBRES
COMPR.		
VERIFIC.		
HOMOL.		

PLANO N°

SUSTITUYE A:

EDICION

TOL.GEN. ISO 2768-cK

ESCALA 1/10

DESIGNACION:

DYNAMIC ENVELOPE

HOJA N° 1

N° DE HOJAS 1

APLICACIONES

	FECHA	NOMBRES
DIBUJ.	28-02-2017	M.LARRAÑAGA
VERIFIC	28-02-2017	A.OTERMIN

ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)

REFERENCIA: Q.00.238.00.040

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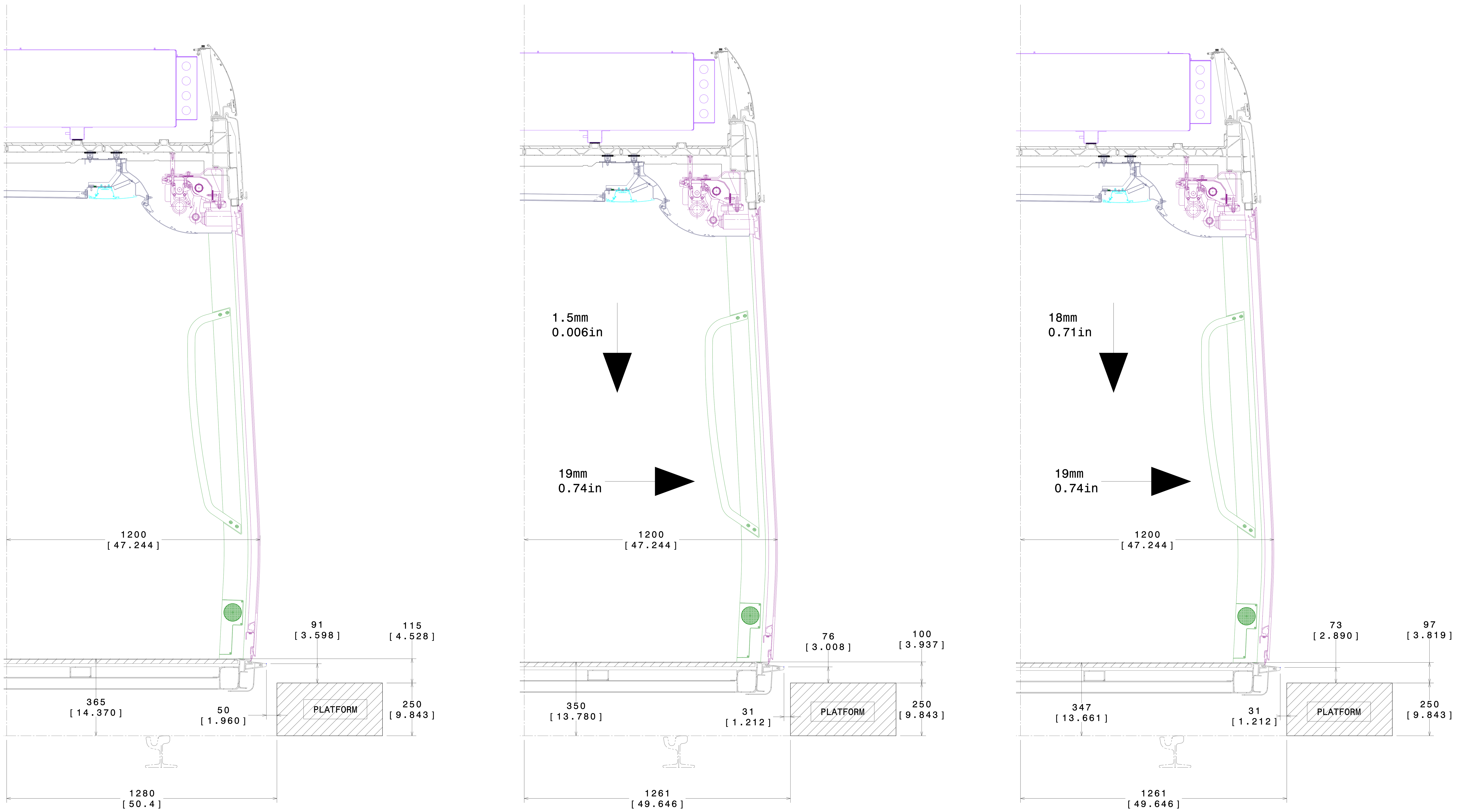

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	VERIFIC.			
	HOMOL.			
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	TOL.GEN. ISO 2768-cK	ESCALA 1/10	DESIGNACION: ACCESSIBILITY	HOJA N° 1 / N° DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.00.045
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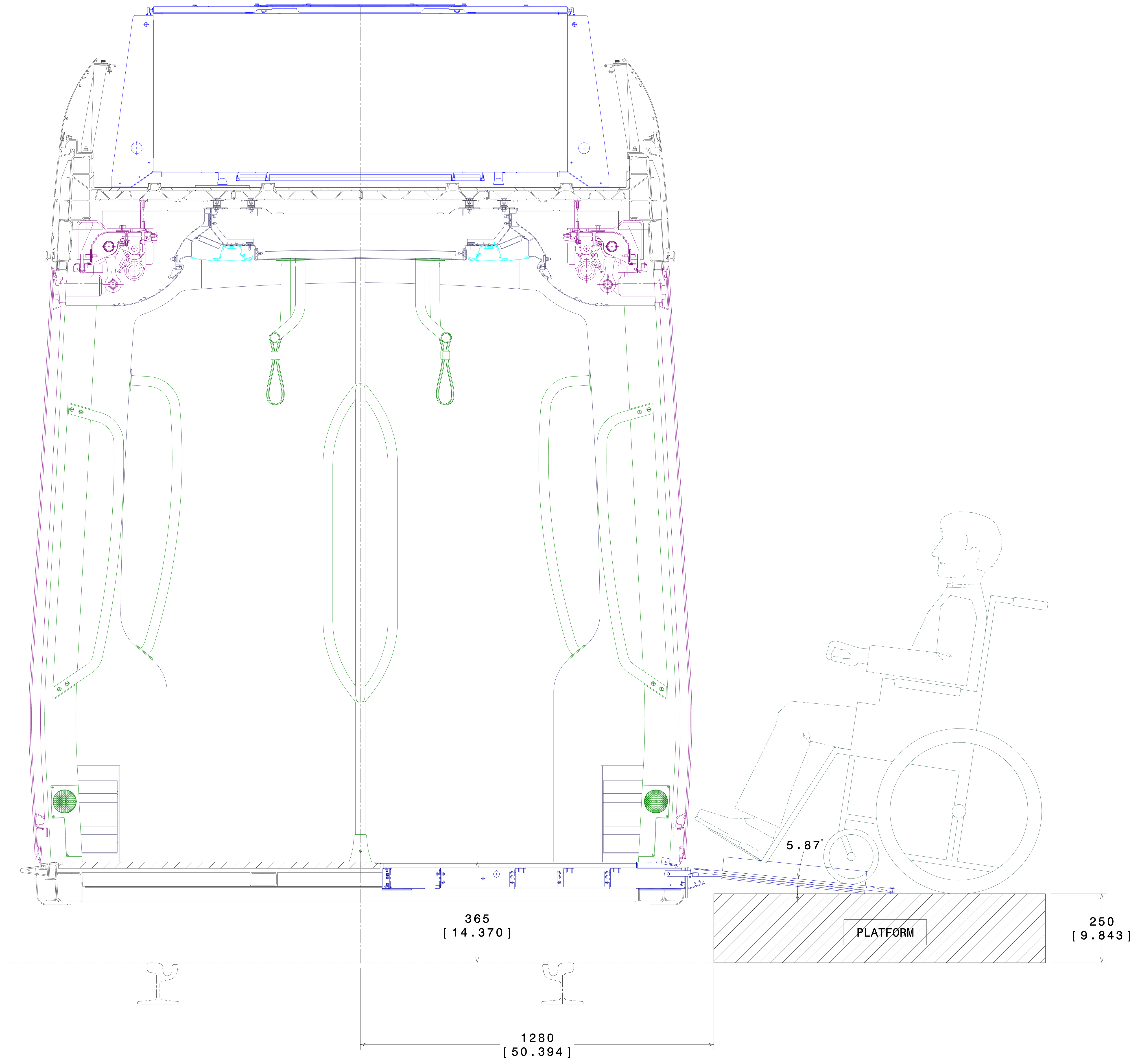

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	HOMOL.			
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			DESIGNACION: ACCESSIBILITY WHEELCHAIR USER	HOJA Nº 1 / Nº DE HOJAS 1
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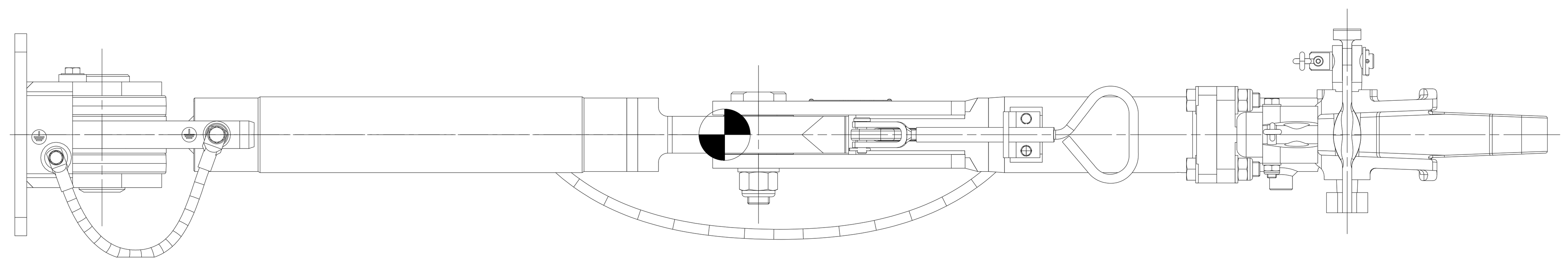

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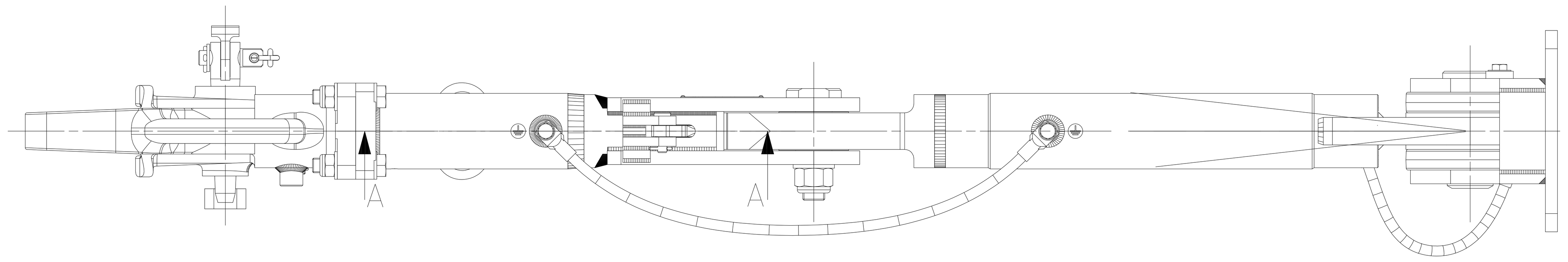

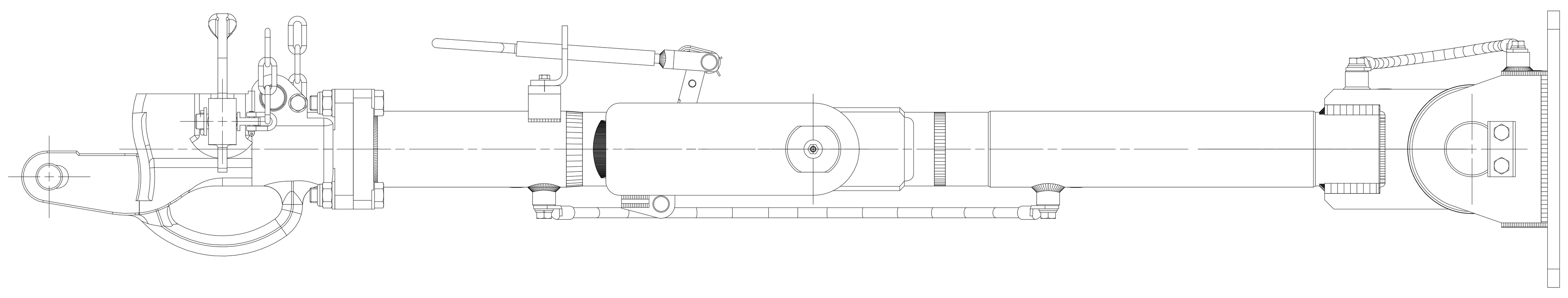

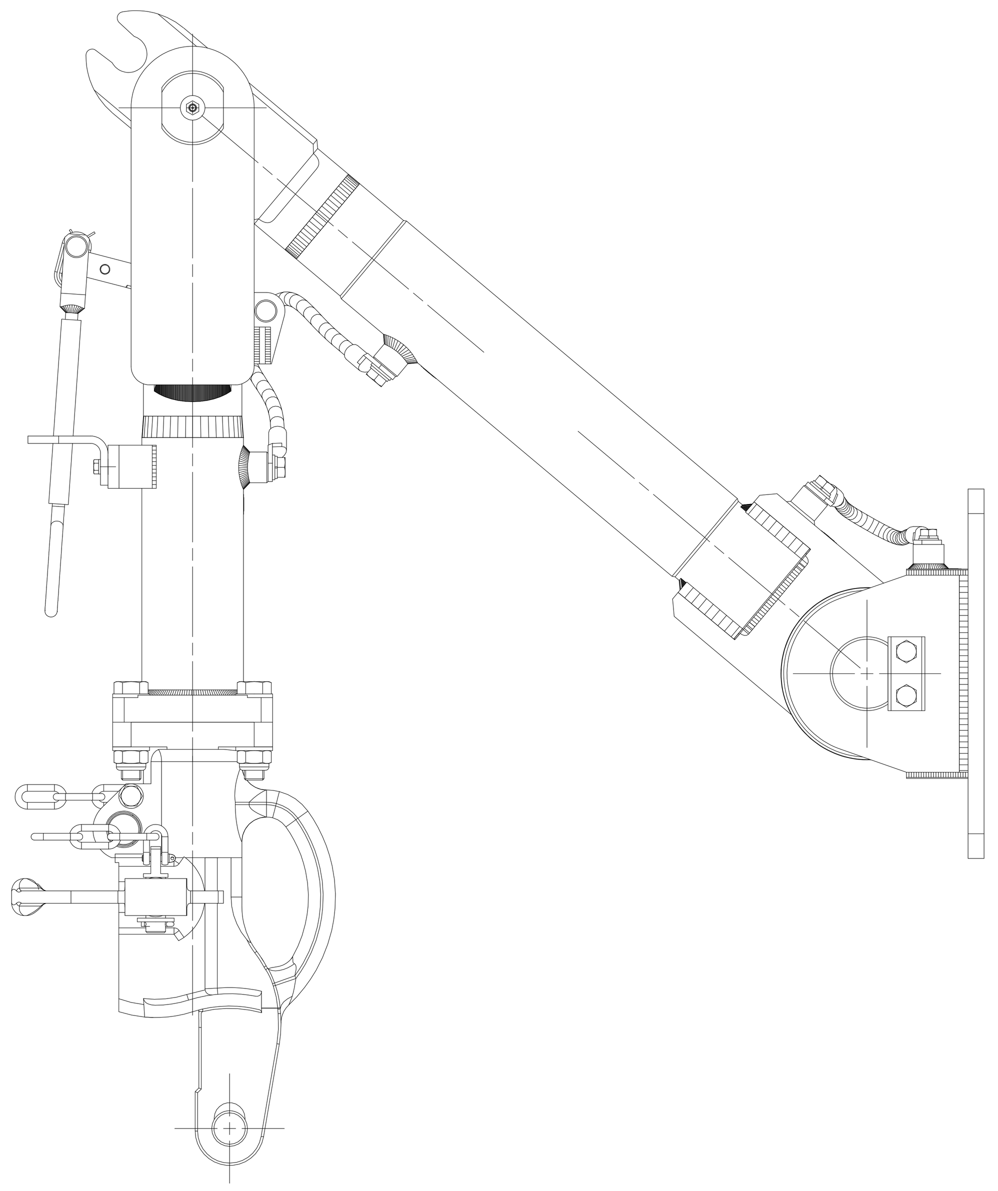

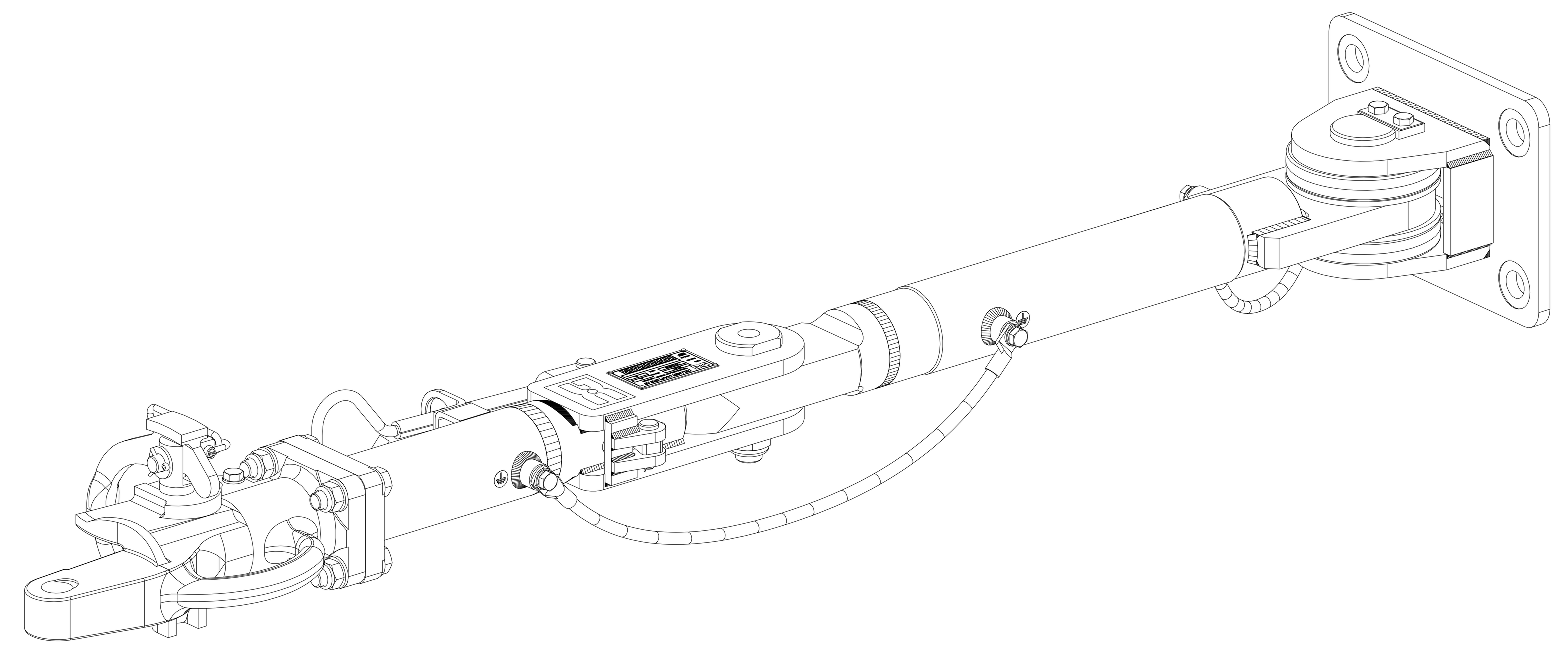

MODIFICACIONES				
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COMPR.			PLANO Nº	
VERIFIC.				
HOMOL.				
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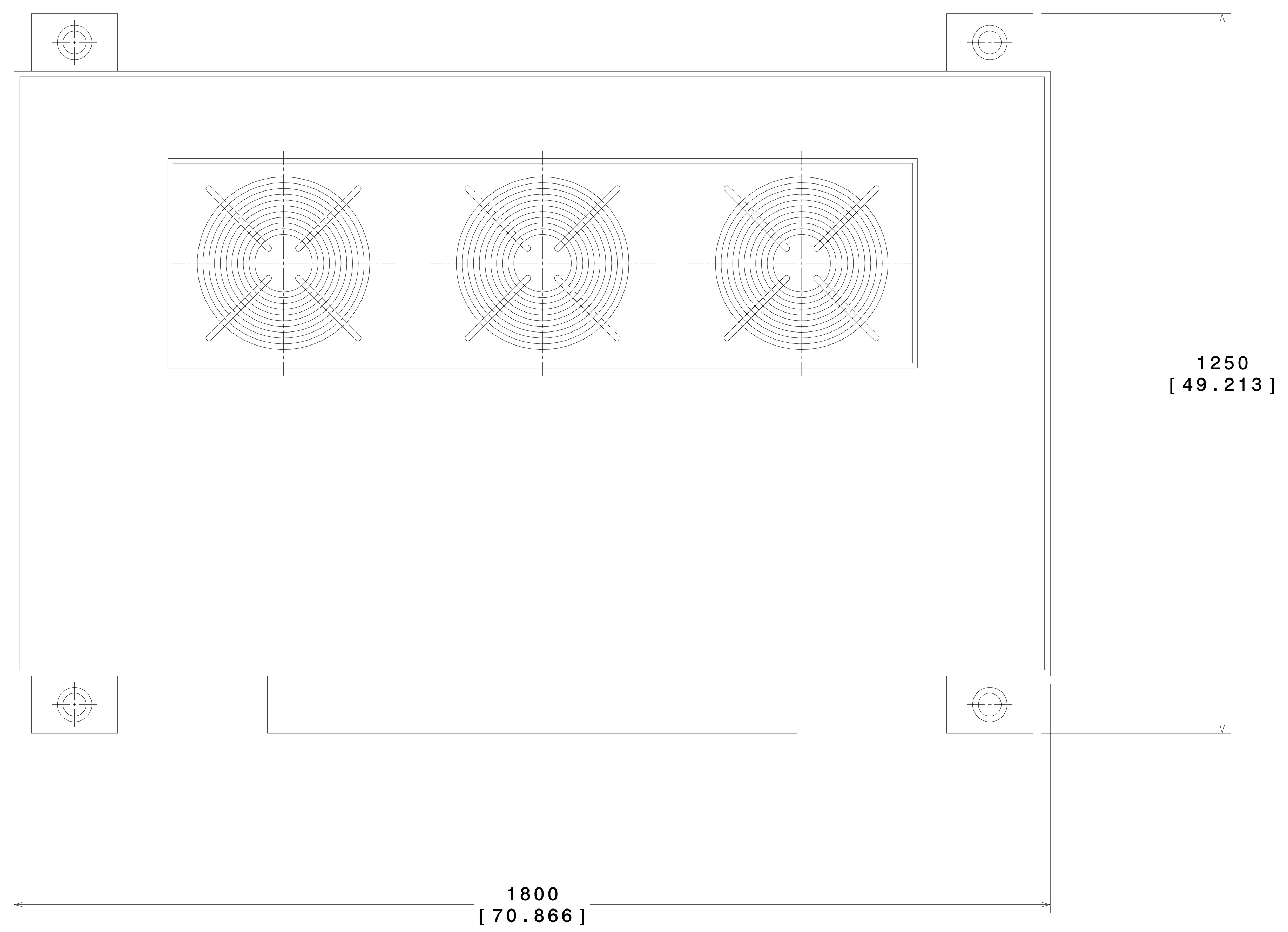
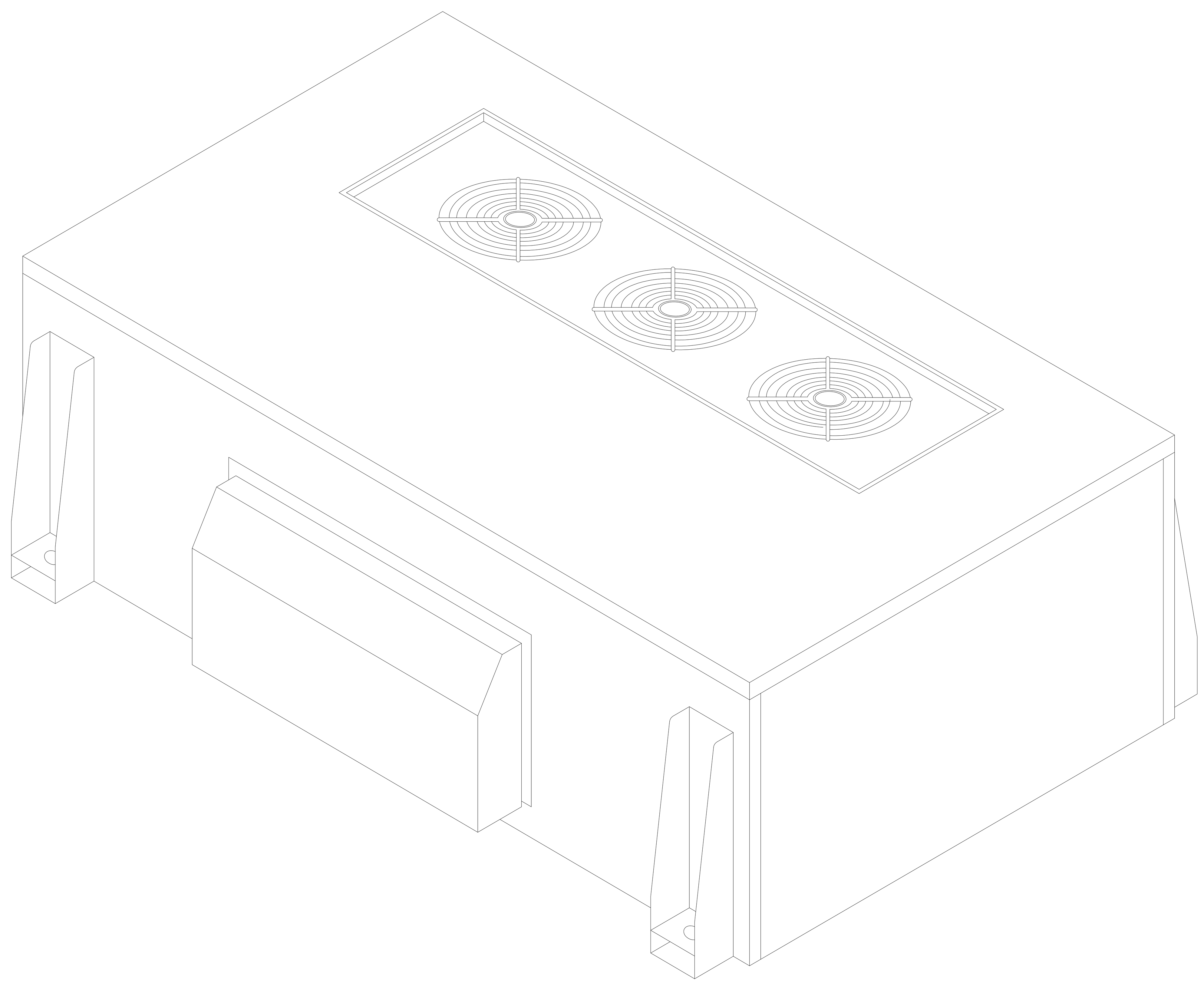
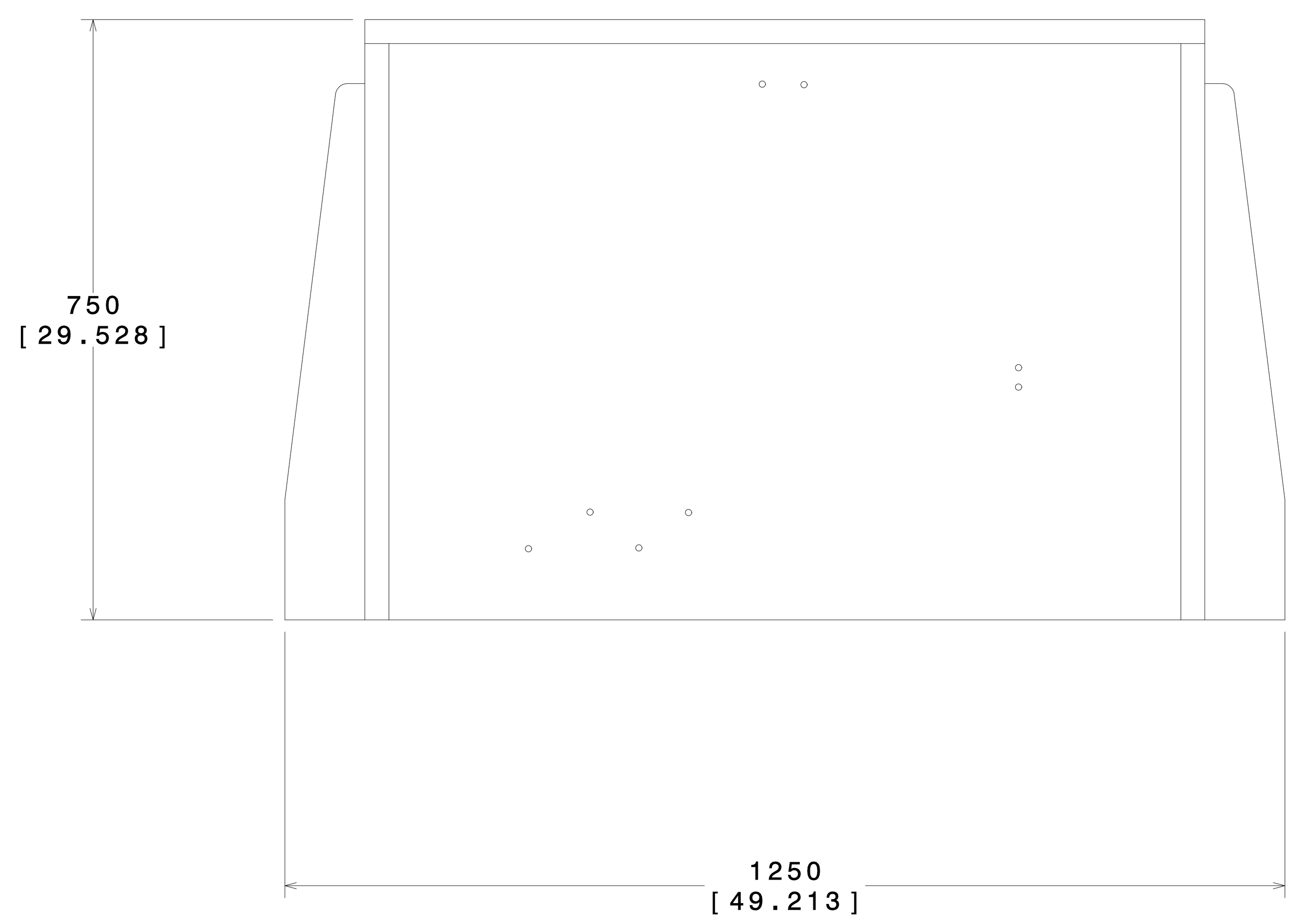
TOL.GEN.	ESCALA		DESIGNACION:	HOJA Nº 1
ISO 2768-cK	1/5		COUPLER	Nº DE HOJAS 1
APLICACIONES	FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)	
DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.18.001	
VERIFIC.	28-02-2017	A.OTERMIN		
-FIRST HILL STREETCAR-			SUSTITUYE A :	EDICION







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	VERIFIC.			
	HOMOL.			
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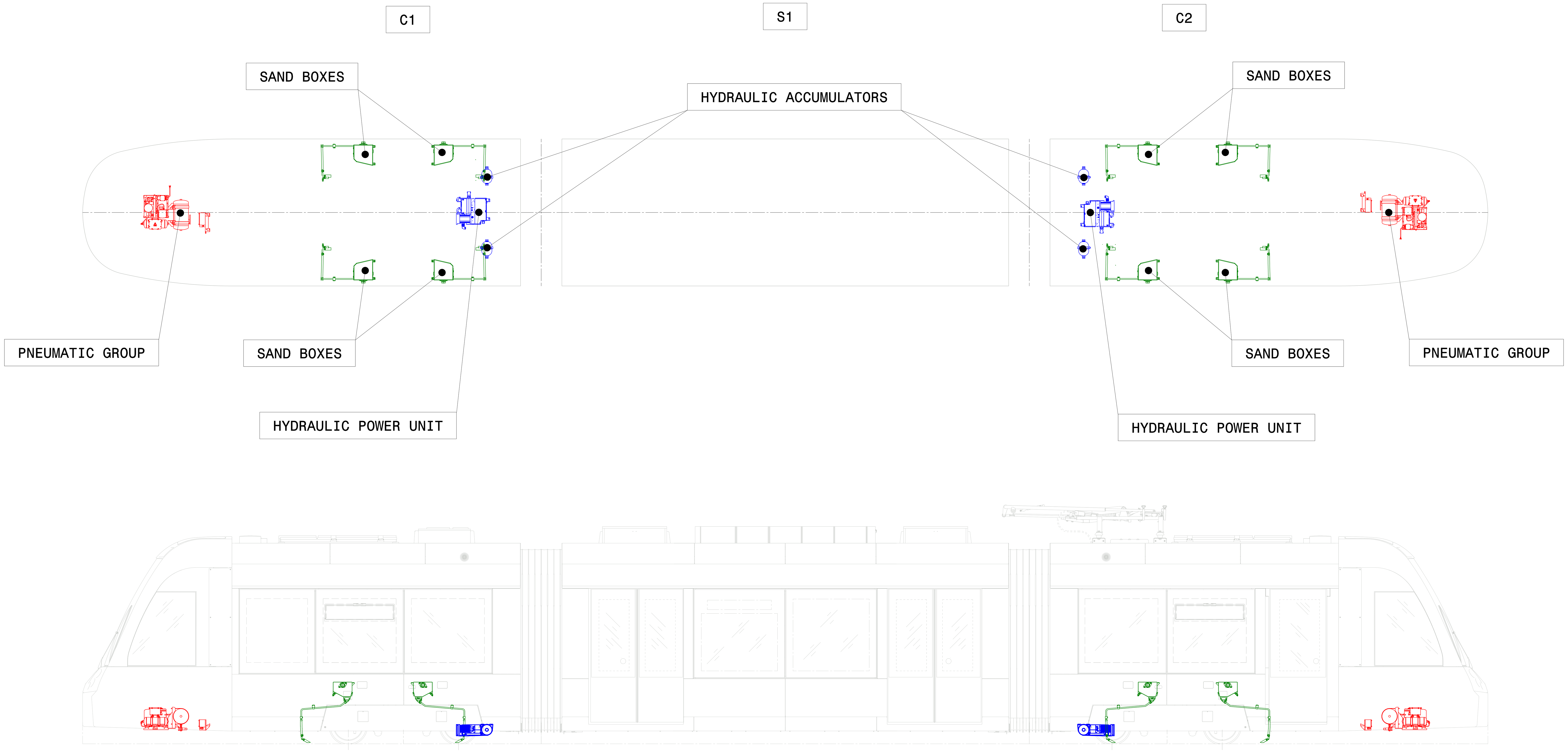
	TOL.GEN. ISO 2768-cK	ESCALA 1/5	DESIGNACION: HVAC	HOJA Nº 1 / Nº DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.66.001
	VERIFIC.	28-02-2017	A.OTERMIN	
-FIRST HILL STREETCAR-	SUSTITUYE A :			EDICION



MODIFICACIONES		FECHA	NOMBRES	PLANO Nº	
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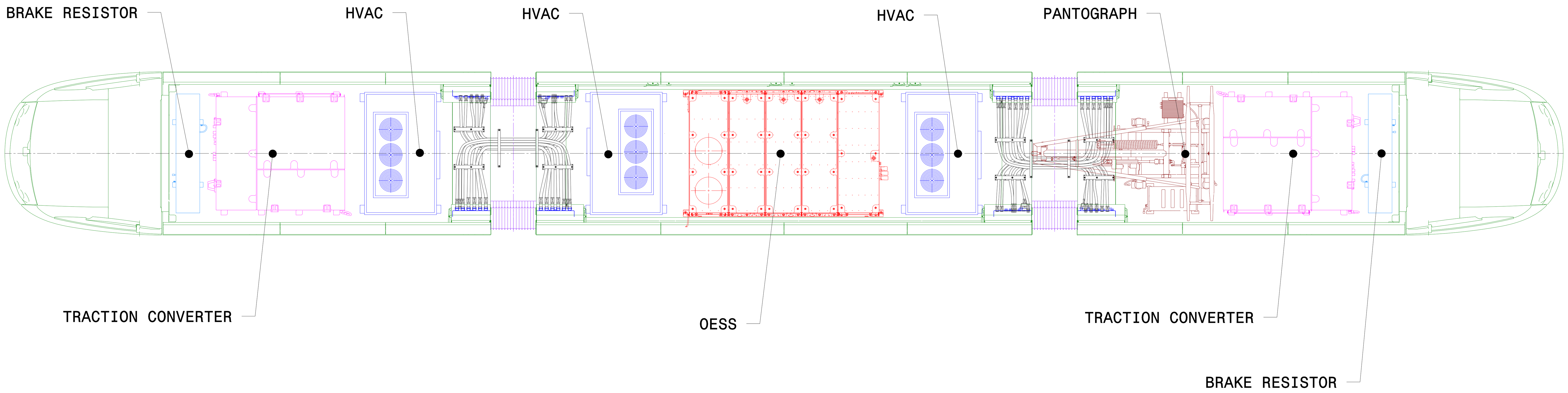
	VERIFIC.				
	HOMOL.				
				SUSTITUYE A:	EDICION
	TOL.GEN. ISO 2768-cK	ESCALA 1/40		DESIGNACION: UNDERFRAME EQUIPMENT ARRANGEMENT	HOJA Nº 1 / Nº DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF — CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)	
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.72.001	
	VERIFIC.	28-02-2017	A.OTERMIN		
-FIRST HILL STREETCAR-	SUSTITUYE A :				EDICION



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	VERIFIC.			
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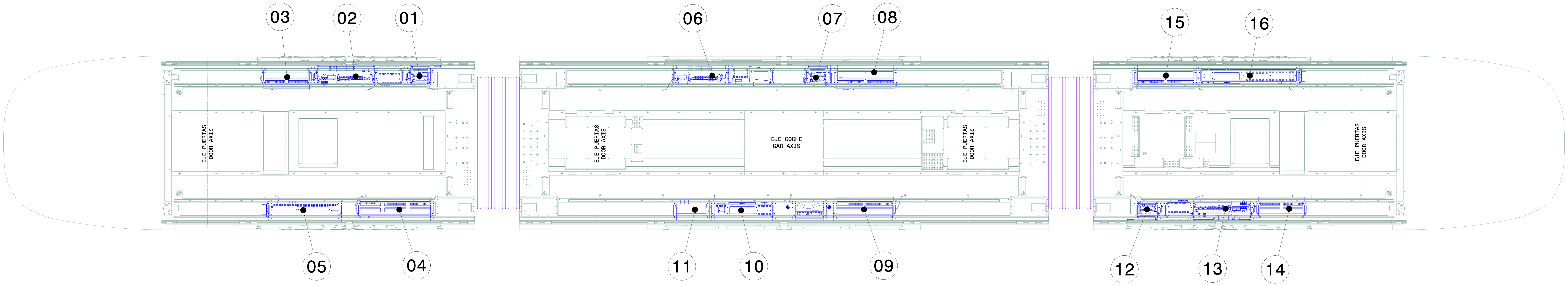
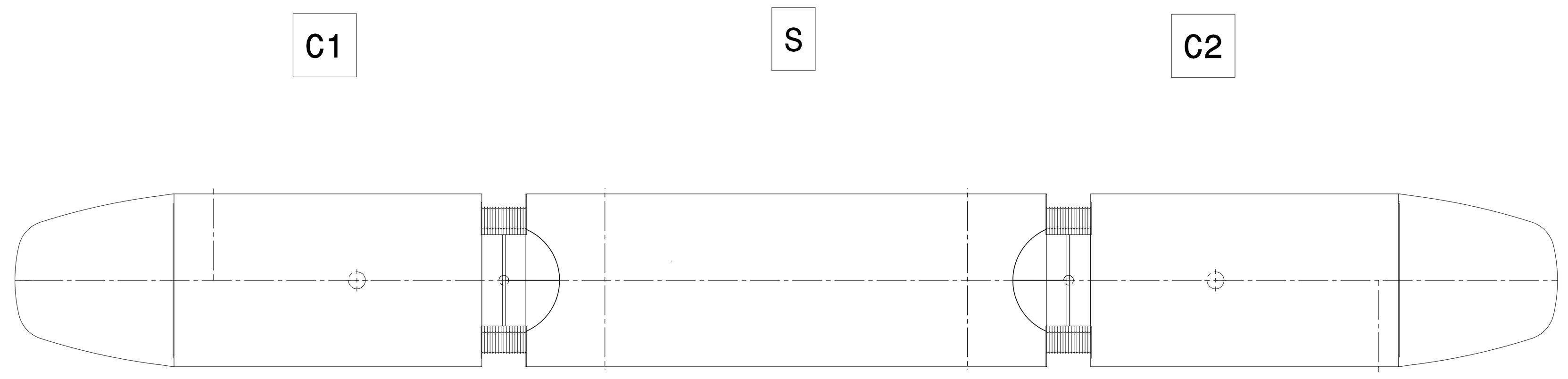
			SUSTITUYE A:	EDICION
	TOL.GEN. ISO 2768-cK	ESCALA 1/40	DESIGNACION: ROOF EQUIPMENT	HOJA N° 1 / N° DE HOJAS 1
APLICACIONES		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	27-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.73.001
	VERIFIC.	27-02-2017	M.LOPETEGI	
FIRST HILL STREETCAR	SUSTITUYE A :			EDICION





ITEM	DESCRIPTION	QTY.	CODIFICATION OR STD.	MATERIAL	lb/Kg WEIGHT	in/mm DIMENS.
			DRAWING N° OR MATERIAL QUALITY:		NOTES AND OBSERVAT.	
1 6	SWITCHES PANEL PANEL DE SWITCHES					
1 5	TERM.BLOCK PANEL XT2SALC2L PANEL DE REGLETA XT2SALC2L					
1 4	TERM.BLOCK PANEL XT1SALC2R PANEL DE REGLETA XT1SALC2R					
1 3	MAGN. & CONTACTORS PANEL PANEL TERMICOS Y CONTACT.					
1 2	RELAYS PANEL PANEL RELES					
1 1	ELECTRONICS PANEL II PANEL ELECTRONICAS II					
1 0	ELECTRONICS PANEL I PANEL ELECTRONICA I					
0 9	TERM.BLOCK PANEL XT2SALS1L PANEL DE REGLETA XT2SALS1L					
0 8	TERM.BLOCK PANEL XT1SALS1R PANEL DE REGLETA XT1SALS1R					
0 7	RELAY PANEL ASSEMBLY S CTO. PANEL DE RELES S					
0 6	MANG. & CONTACTORS PANEL PANEL TERMICOS Y CONTACT.					
0 5	SWITCHES PANEL PANEL DE SWITCHES					
0 4	TERM.BLOCK PANEL XT2SALC1L PANEL DE REGLETA XT2SALC1L					
0 3	TERM.BLOCK PANEL XT1SALC1R PANEL DE REGLETA XT1SALC1R					
0 2	MAGN. & CONTACTORS PANEL PANEL TERMICOS Y CONTACT.					
0 1	RELAYS PANEL PANEL RELES					
0 0	EQUIP. IN LATERAL PANELS MONT.APARATOS EN BATIENTES					

MODIFICACIONES

	FECHA	NOMBRES
COMPR.		
VERIFIC.		
HOMOL.		

PLANO N°

SUSTITUYE A:

EDICION

TOL.GEN ISO 2768-cK

ESCALA 1/10

DESIGNACION:

PRELIMINARY INTERIOR EQUIPMENT ARRANGEMENT

HOJA N° 1

N° DE HOJAS 1

APLICACIONES

	FECHA	NOMBRES
DIBUJ.	28-02-2017	M.LARRAÑAGA
VERIFIC.	28-02-2017	A.OTERMIN

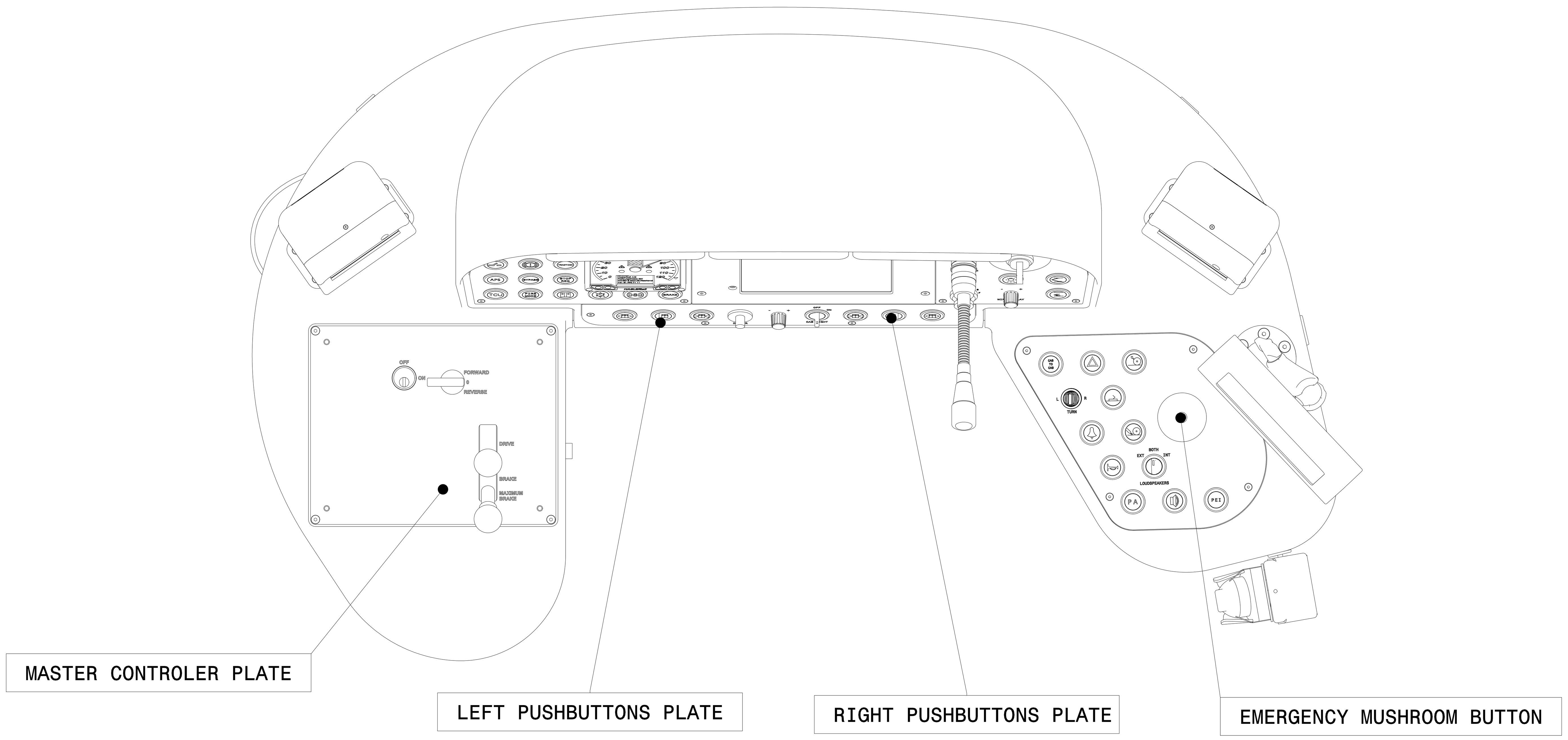
ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)

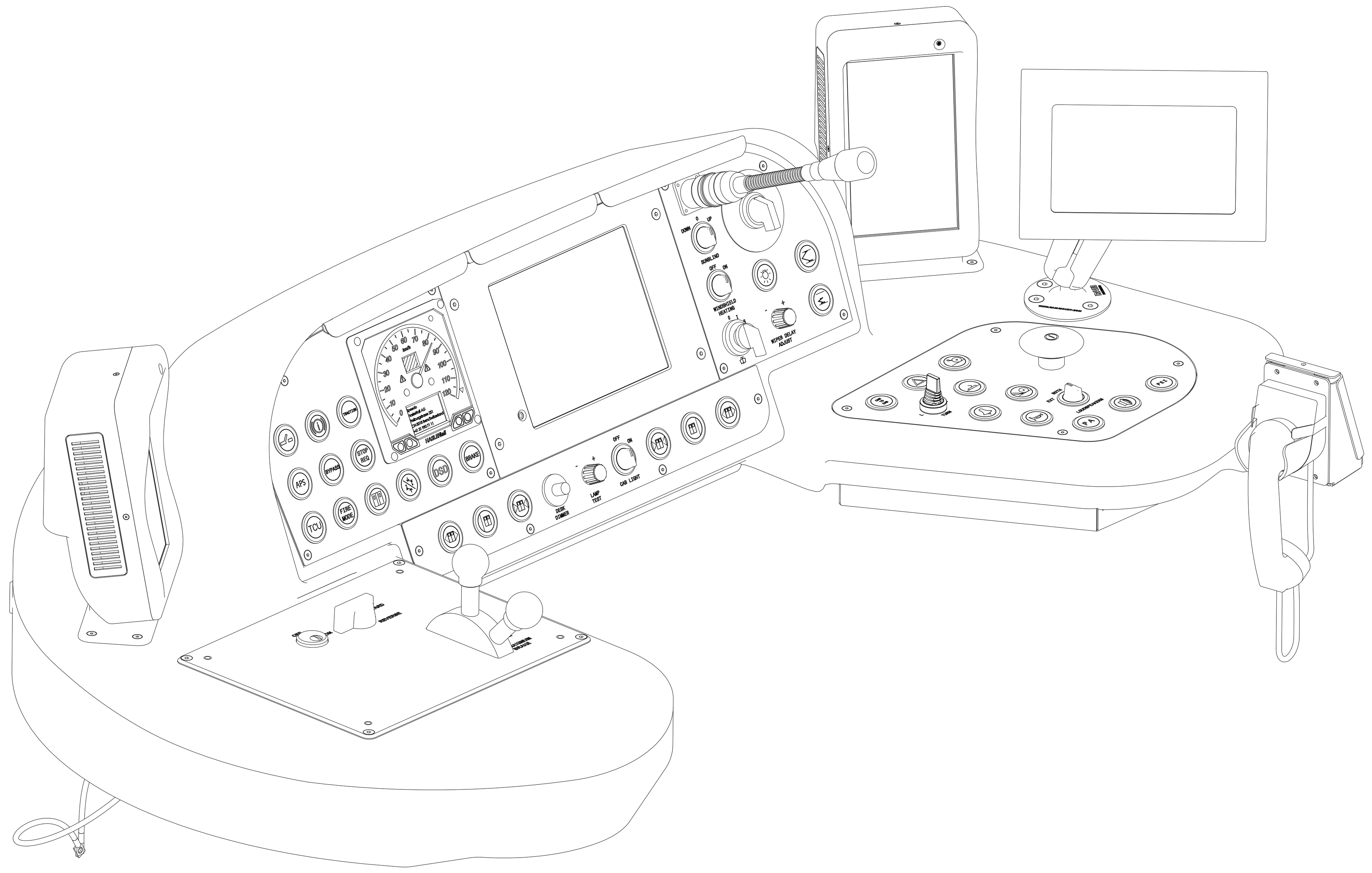
REFERENCIA: Q.00.239.74.001

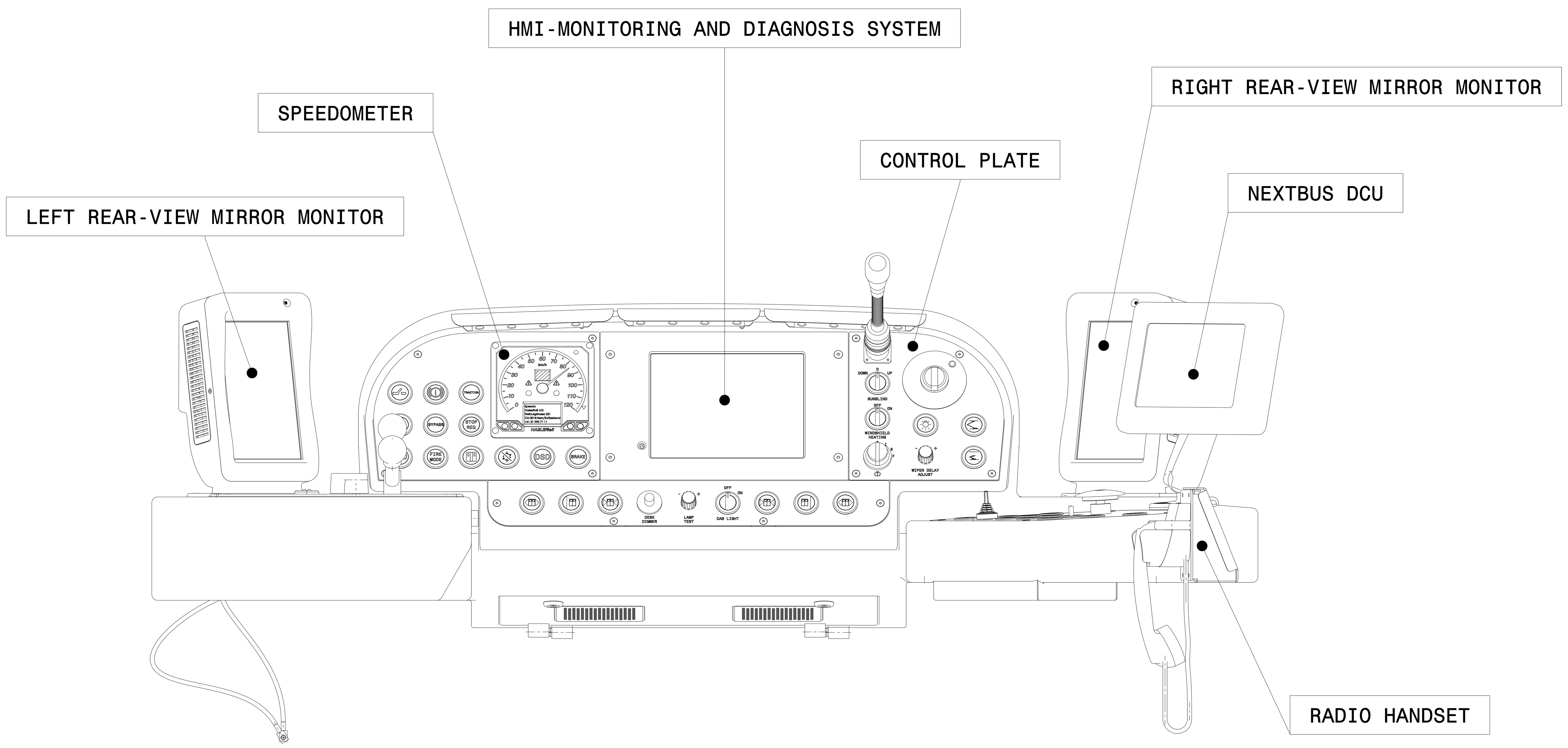
-ST TACOMA-

SUSTITUYE A :

EDICION







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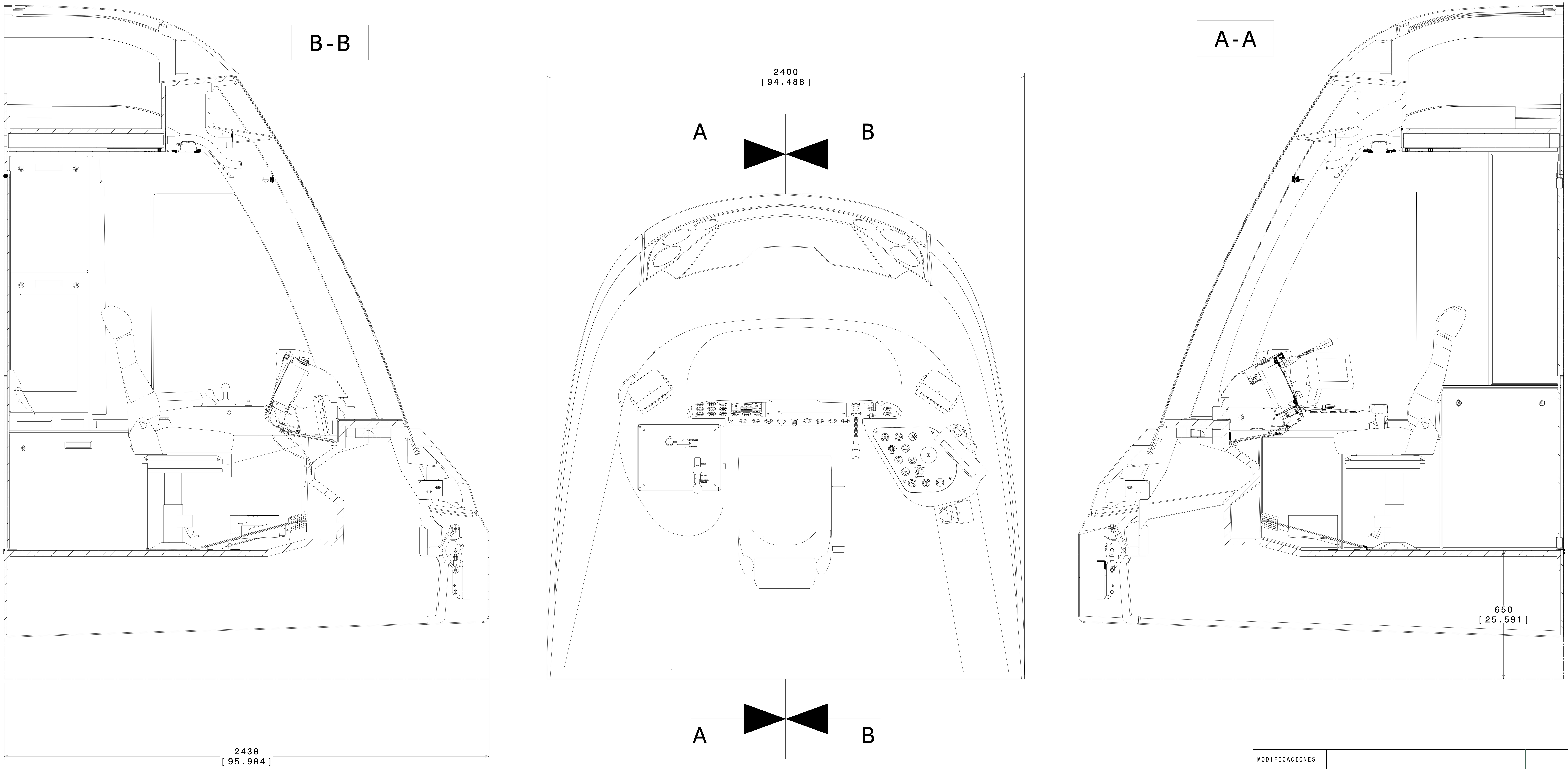
	COMPR.			
	VERIFIC.			
	HOMOL.			
			SUSTITUYE A:	EDICION
	TOL.GEN	ESCALA	DESIGNACION: OPERATOR CONSOLE	HOJA N° 1
APLICACIONES	ISO 2768-cK	1/5		N° DE HOJAS 1
		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.86.001
	VERIFIC.	28-02-2017	A.OTERMIN	
-FIRST HILL STREETCAR-	SUSTITUYE A :			EDICION



MODIFICACIONES					
		FECHA	NOMBRES		
	COMPR.			PLANO N°	
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	TOL.GEN.	ESCALA	DESIGNACION: GENERAL CAB ASSEMBLY		HOJA N° 1
APLICACIONES	ISO 2768-cK	1/10			N° DE HOJAS 1
		FECHA	NOMBRES	ENTIDAD: CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES, S.A. BEASAIN (GIPUZKOA)	
	DIBUJ.	28-02-2017	M.LARRAÑAGA	REFERENCIA: Q.00.238.87.001	
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Sub-Part B – ONBOARD ENERGY STORAGE SYSTEM (OESS)

Sub-Part B – ONBOARD ENERY STORAGE SYSTEM (OESS)

1.A ONBOARD ENERGY STORAGE SYSTEM OESS

The ACR system, the trade-name for the OESS designed by CAF Power &Automation (CAF P&A), responds to a growing market demand for vehicles (trams, streetcars, LRVs, etc.) running in catenary-free sections with increased energy savings. Its high configurability and scalability allows the system to be adapted to any type of line, even if the catenary-free section is extended during the life of the vehicle.

Additionally, CAF P&A is committed to helping its customers reduce operational expenses, therefore, OESS system may be also employed for improving energy recovery capability in sections with overhead catenary.

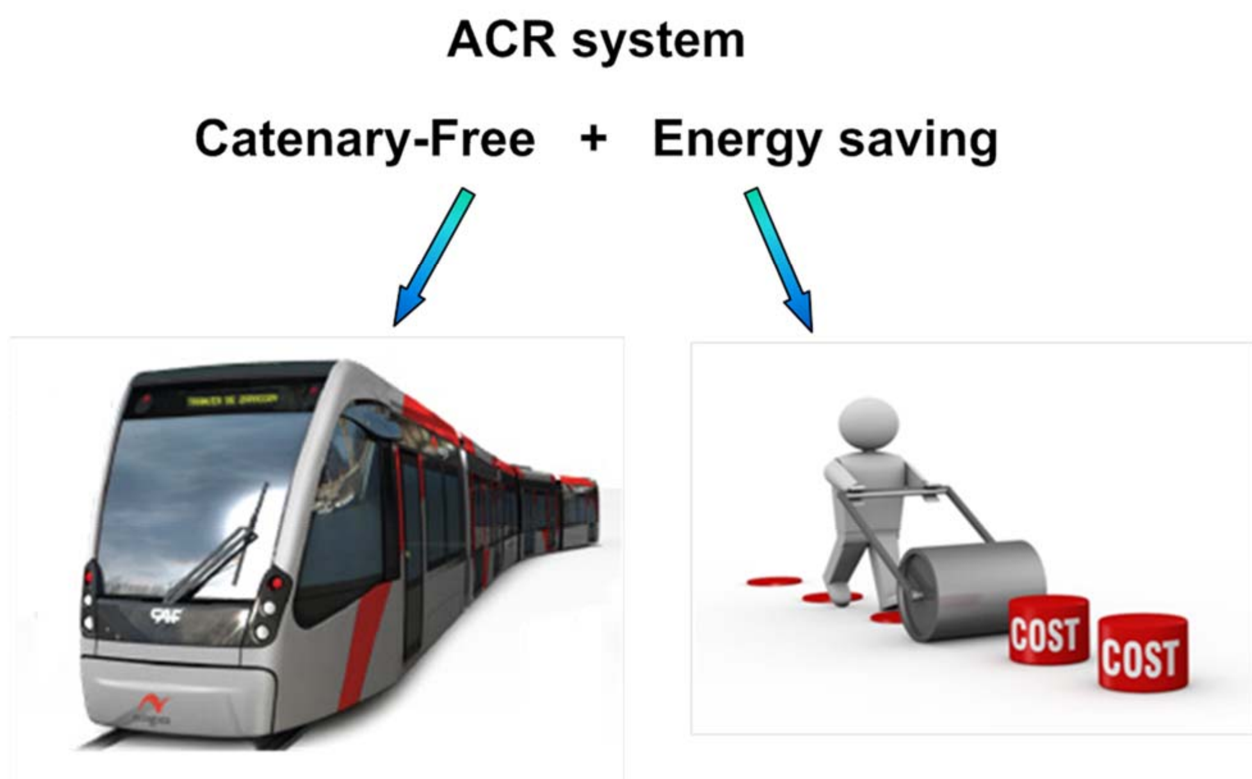


Figure 1. *OESS System main functionalities*

CAF's OESS system is designed so that it does not negatively affect availability; to that end, a high level of redundancy has been designed into the system. It should be remarked that the vehicles equipped with our OESS system (in service since 2010), have showed similar availability rates as conventional vehicles.

1.A.1 OESS SYSTEM DESCRIPTION

In contrast to most of the OESS systems available on the market, CAF P&A's solution can be configured to employ several technologies at a time. This applies mainly to Supercapacitors (also called Ultracapacitors) and lithium ion batteries which are typically combined to meet the power and energy requirements.

The OESS system has been designed as a standalone system to simplify its integration with other systems, even on existing vehicles. When power is no longer available from the catenary, the OESS system supplies the power and energy required for operation.

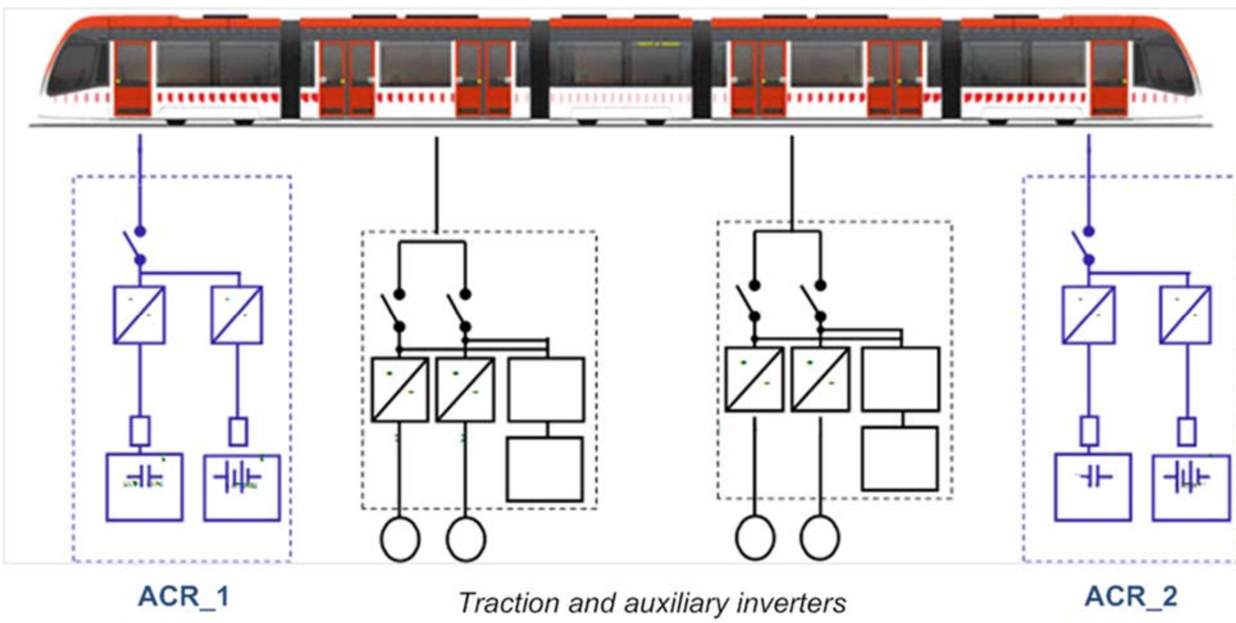


Figure 2. *OESS system integration in a streetcar*

The OESS system in a vehicle has one or more OESS boxes connected in parallel to the catenary or third rail power source. Every OESS box is made of different units to meet the needs and requirements of the specified service

- Power Converter Unit – consisting of a 'dual buck-boost DC/DC' where the power may flow in either of the two directions. This feature permits smaller energy modules leading to higher adaptability and higher redundancy. The 'dual DC/DC' concept splits the energy content into primary and secondary power sources. Please refer to section B.2 of this document for further information regarding the power converter unit.
- Energy Storage Unit – may include Ultracapacitor modules, lithium-ion battery modules or a combination of both. The type and quantity of energy storage modules is configured according to each customer's power and energy requirements. Please refer to section B.3 of this document for further information regarding the Energy Storage unit.
- Battery Active Cooling Unit – applies only when lithium ion based technology is used. It allows cooling the system to the required target temperature, regardless of weather conditions. Please

refer to section B.4.5.1 of this document for further information regarding the Battery Active Cooling unit.

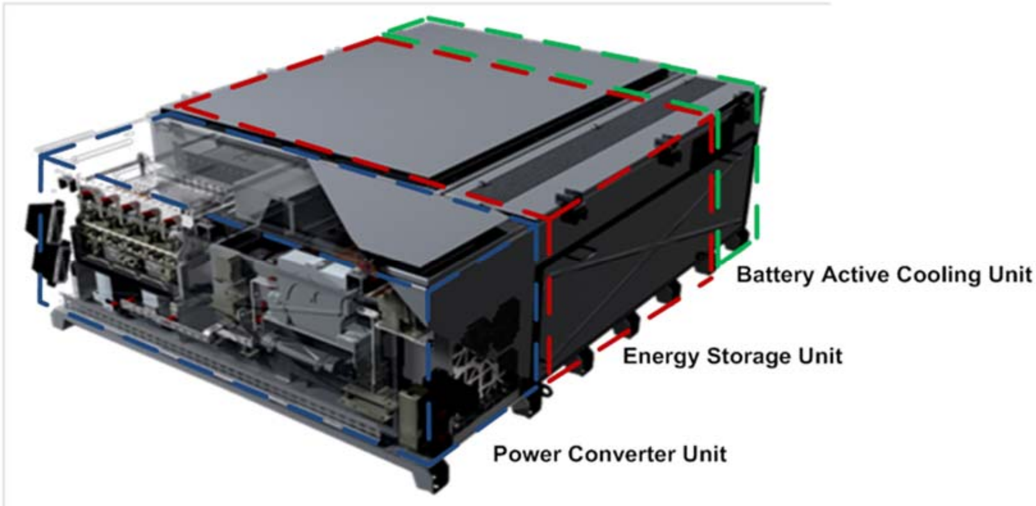


Figure 3. *OESS system in a streetcar*

Depending on the technology used for the primary power source, the OESS design supports three different configurations: Ultracapacitors, Lithium Ion Batteries, or a combination of both. The following pictures show the concept proposed by CAF P&A to ensure that the expectations of each customer are met.

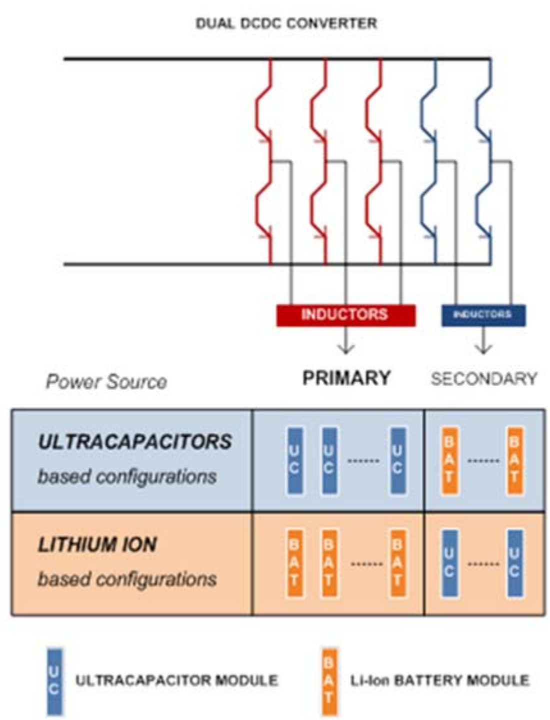


Figure 4. *Example of OESS main configurations by power/energy sources*

1.A.2 POWER CONVERTER UNIT

Energy storage devices are very sensitive to operating conditions, where any unintended use of electrically powered equipment may lead the system to work outside of its recommended operating range. In the proposed design, a DC/DC converter is used to control the power flow between units connected to the different voltage levels:

- Catenary voltage level: corresponds to the voltage level set by the catenary (according to IEC60850 and/or EN50163), and applies to the main electric equipment such as traction and auxiliary inverters.
- Energy storage voltage level: applies to energy storage modules, where a lower voltage level permits the design of smaller modules. As a consequence, onboard energy content may be better adjusted and a higher redundancy is achieved for the same system size.

The OESS system is connected in parallel to the catenary or third rail power source, which means that the system can also be implemented on an existing vehicle as long as there is space available to install it. When there is no catenary supply, the OESS system supplies the energy required for operation.

The power converter contains the following subsystems:

- Main breaker and pre-charge circuit
- Input filter
- DC/DC converter
- Output filter

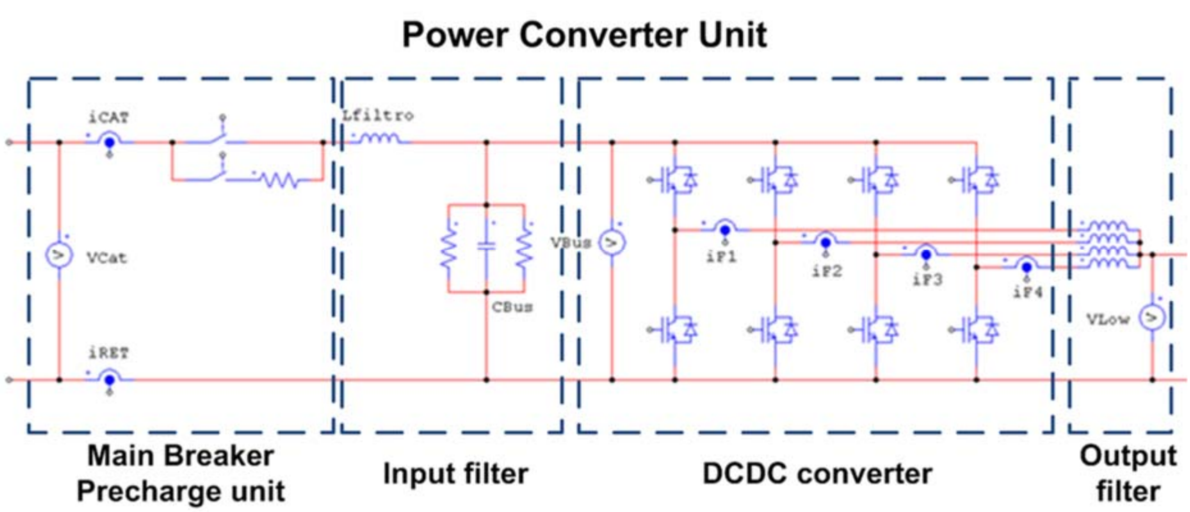


Figure 5. *Electric diagram for power converter unit (single power source)*

Based on IGBT technology the “interleaved multi-channel buck-boost DC/DC” principle is applied, which brings the following features:

- Dual DC/DC: Depending on the power sources employed, its configuration varies. These are the typical configurations used:
  - Four (4) branches of Dual DC/DC used for the primary power source of Ultracapacitors, and one (1) branch of Dual DC/DC used for the secondary power source (of Batteries), or,
  - Three (3) branches of Dual DC/DC used for the primary power source of Ultracapacitors, and two (2) branches of Dual DC/DC used for the secondary power source of Batteries, or,
  - All five (5) branches of Dual DC/DC used for the primary power source (of Ion Lithium)
- High availability: Converter may work even when an error occurs in an IGBT.
- Buck-Boost: Power flow is controlled in both directions: step-up and step-down.

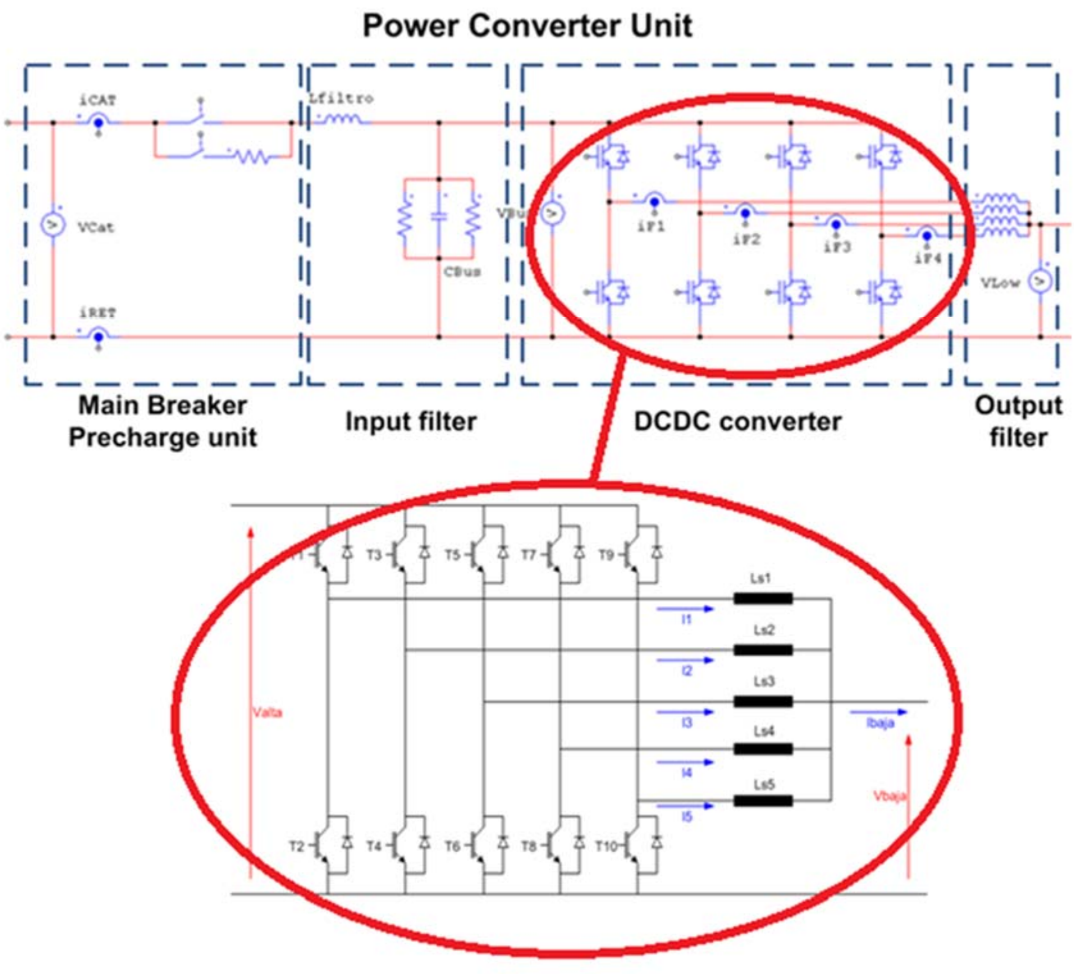


Figure 6. *Example of Dual DC/DC using all 5 branches connected to a single power source*

1.A.3 ENERGY STORAGE UNIT

OESS system technology is based on the capacity of the batteries to store large amounts of energy, with the special feature that by using the appropriate control items, they can both supply and absorb energy.

The accumulator system consists of an association of series – parallel of battery cells to form independent and therefore redundant modules, until the required capacity and energy level is reached.

The sizing of the OESS system is always prepared under non-favorable simulation conditions (high loads, high accelerations/decelerations, etc.). This guarantees correct operation with an appropriate margin even under for exceptional service conditions.

The proposed energy storage system is described in the following section (and throughout this document). As the proposed system for the Center City Connector Streetcar vehicles is based on the Li-Ion batteries, the description will focus only in this technology.

1.A.3.1 BATTERIES

Li-ion technology is based on energy storage by means of an electrolyte which takes all of the necessary ions for the reversible electrochemical reaction between the anode and the cathode. Despite the common belief that Li-ion is a recent technology, this technology has been evolving for over 30 years. Some of the advantages over previous battery technologies are greater energy density, no memory effect and a slow self-discharge.

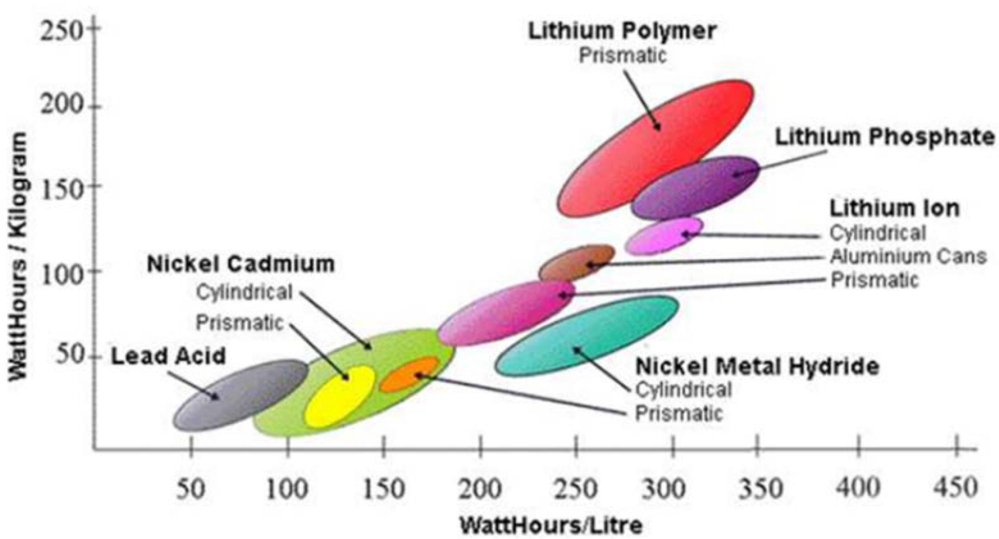


Figure 7. *Energy density chart by battery technology*

These features allowed the development of high performance batteries of various shapes and capacities for consumer electronics. Since first commercialized in the 1990s, Li-ion technology has become popular for use in devices such as cellular phones, portable computers and PDAs. In transportation applications, Li-ion is considered as a key technology in hybrid and fully electric vehicles due to the increasing cost of oil and clean environment policies.

However, batteries based on lithium ion have drawbacks, such as instability when overcharged, and narrow operating temperature windows to achieve maximum performance. For safe operation, these problems must be controlled by means of a Battery Management System (BMS), which is in charge of checking that all charge-discharge operations are run within the allowable range.

Despite the wide variety of chemistries and companies found in the market, CAF P&A relies only on reliable and reputable companies that produce top quality batteries. Then, an exhaustive qualification process is performed on a cell and module basis. The following main variations of Lithium Ion batteries that CAF P&A has already evaluated, tested, and qualified are:

LTO	**LITHIUM TITANATE OXIDE**
NMC	**LITHIUM NICKEL-MANGANESE-COBALT OXIDE**
LMO	**LITHIUM MANGANESE OXIDE**
LFP	**LITHIUM IRON PHOSPHATE**

For each application, CAF P&A selects the technology that best fits the overall requirements.

1.A.4 OESS SYSTEM CONTROL

CAF P&A has system integration experience on many projects in revenue service which has resulted in a wealth of expertise in optimizing the trade-off between system performance, and reliability and life-cycle-cost.

The control electronics continuously monitor and calculate all of the relevant data for each individual cell and module (e.g. state-of-charge, state-of-health, temperature, etc.). This information, together with a complex balancing strategy, permits accurate control, which results in a high availability rate, and an extended life span.

1.A.5 WARRANTY, LIFE EXPECTANCY AND END-OF-LIFE DETERMINATION

According to Article 13.2.C of the Special Provisions, the warranty period for the OESS shall be one (1) year after Conditional Acceptance for each car.

As previously mentioned, energy storage systems are very sensitive to working conditions, therefore lifetimes may vary depending on the line and operation characteristics. However, CAF P&A and its suppliers are committed to achieving a long life span under different approaches:

- Aging rate: reducing the effect of the aging factors by monitoring and adjusting the system working conditions in real-time.
- End-of-life determination: reducing the sensitivity to component characteristics variation over its life.

Typically, the following characteristics of the energy storage devices vary over its lifetime:

- Capacity: refers to a capacity loss effect over the time.
- ESR or equivalent-serial-resistance: refers to the internal resistance increase.

Designs from CAF P&A guarantee normal operation even when a high variation of its original characteristics takes place. At a very late stage, the system will slowly and progressively decrease in performance, available power and energy, especially under hot ambient temperature conditions. The need to replace the energy storage system will be according to the customer's acceptance criteria for downgraded vehicle performance.

1.A.6 HOW IT WORKS - LITHIUM-ION AS PRIMARY POWER SOURCE

Under this configuration, the vehicle charges the energy storage unit before entering the off-wire section. Upon entering the catenary free section, the required energy for traction and ancillaries is supplied from the energy storage unit. When the vehicle re-enters the section with overhead line, it recharges the energy storage unit.

In a typical line profile, a vehicle requires a high peak of power for acceleration. To that end, ultracapacitor modules may optionally be included as a secondary power source in order to ensure power availability and improve the overall vehicle performance.

Additionally when the vehicle runs within a catenary section, the ultracapacitors can be employed with priority over brake resistors to increase the energy savings rate.

Figure 8. *Streetcar operation for Li-Ion based configurations*

1.B PROPOSED OESS

1.B.1 CHARACTERISTICS OF THE PROPOSED EQUIPMENT

Several line simulations have been performed, in the worst conditions, to estimate the energy requirements based on the conditions established for dimensioning. Per the conclusions obtained from these simulations, CAF P&A proposes the system described below.

The OESS Freedrive system consists of one equipment box in which the battery modules are included.

OESS FREEDRIVE OFFERED EQUIPMENT (1 unit in a 3 module streetcar)	
Number of Lithium-Ion batteries branches	3
Cooling system for batteries	Active cooling unit
Maximum power	330 kW
Onboard Stored Energy	3 x 22 kWh

OESS FREEDRIVE OFFERED EQUIPMENT (1 unit in a 3 module streetcar)	
Nominal Voltage	750V
Dimensions of the OESS system:	1845 x 750 x 2987
Weight of the OESS system	2288 kg
Material	Aluminum + Stainless Steel.
Expected service	80 000 km/year*

Therefore, to be able to go over each of the off wire sections, 66 kWh of battery energy will be available.

1.B.2 OPERATIONAL CHARACTERISTICS OF THE OFFERED OESS SYSTEM:

OESS FREEDRIVE OFFERED EQUIPMENT (1 unit in a 3 module streetcar)	
Temperature Operating range	-30ºC min / +55ºC max
Maximum charging power	24.6 kW
Nominal charging voltage	750 V
Charging current @ nominal voltage	35.2 A
Onboard Stored Energy	3 x 22 kWh
Charging time (full battery)	0.5 h

1.B.3 INSTALLATION OF THE OESS

The OESS system will be installed in the central car, as shown in the following figure:

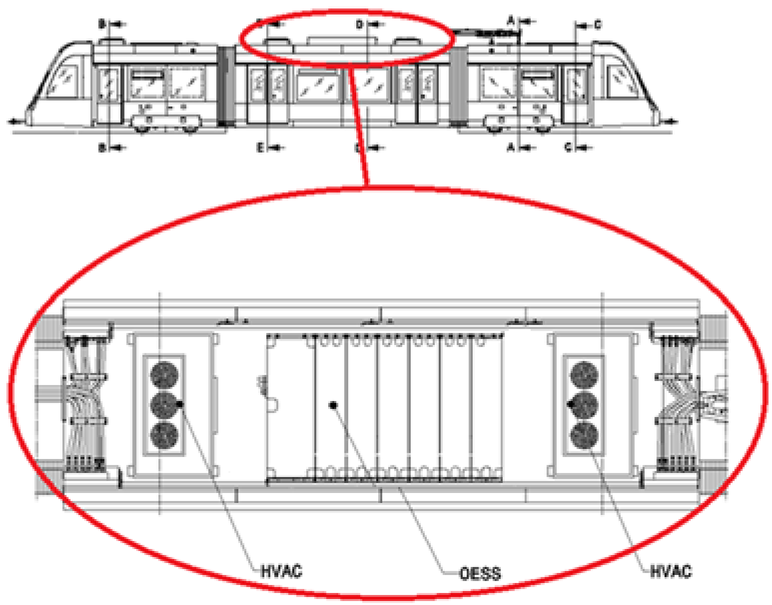


Figure 9. *OESS system installation drawing on the S1 (central car) module*

1.B.4 OESS SIZING: CAPACITY, CHARGING AND DISCHARGING RATES, AND TIMES

1.B.4.1 SIMULATION METHODOLOGY

CAF P&A utilizes a proven methodology to determine the dimensions of the equipment. It consists of defining two different cases; the worst case operation and a nominal case operation.

It is assumed that the streetcar will operate in the nominal case, 90 percent of the time and operate in the worst case, 10 percent of the time.

The simulations in the nominal case of operation are used to size the life of the proposed system. To this end, the simulations have considered average operating conditions. A nominal load of the vehicle has been considered (AW2) as well as a nominal consumption of auxiliary power. In this scenario, the batteries will only be permitted to work in the frequent working condition range.

The simulations in the worst case operation are used to guarantee the correct sizing of the OESS system from an energy point of view, considering the most demanding operating conditions. In this case, the batteries will be allowed to work outside of the frequent working condition range. The worst case operation has been checked in accordance with the performance requirements established by the customer in the section 2.7 of the technical specification.

This methodology has the aim of maximizing the life of the proposed equipment while guaranteeing operation under exceptional operating circumstances.

Listed below are the sizing conditions for the nominal case of operation. These energy requirements should cover, at least, 90% of the operating cases. If this is not the case, CAF must be notified by the customer so that the attached maintenance plan can be reevaluated and revised as necessary.

1.B.4.2 CATENARY-FREE ROUTE

The simulation has been done for the line:

Broadway & Denny - Fairway Ave & Aloha St - Broadway & Denny

Wireless Segments
Broadway and Denny to South Jackson and Occidental Stations
Jackson and Occidental to First and Cherry Stations
Stewart and 2nd to Westlake and 6th Stations
Stewart and 2nd to Jackson and Occidental Stations

1.B.4.3 SIZING CONDITIONS FOR THE NOMINAL CASE OF OPERATION

The equipment is sized to operate according to the conditions explained below:

- Streetcar configuration: C1-S-C2 (3 modules).
- Route: As defined in the alignment profile and including stops due to traffic lights and crossings, according to the requirements of the technical specification.
- Performance curves as defined
- Load: AW2 (4 p/m^2)
- Rotary inertia: 6.87% tare.
- Gear-box ratio: 5.44
- Rated wheel diameter: 585 mm.
- Dwell time: 30 seconds
- Number of unexpected stops: 1 per section during 20 seconds (10 stops in each segment)
- Jerk: 2 m/s3.
- Total brake rate: 1.34 m/s2
- Simulation mode: All-Out maximum performance.
- Non-compensated (lateral) acceleration: 1 m/s2.
- Maximum average auxiliary power in the off wire section: 30 kW.

1.B.4.3.1 RESULTS

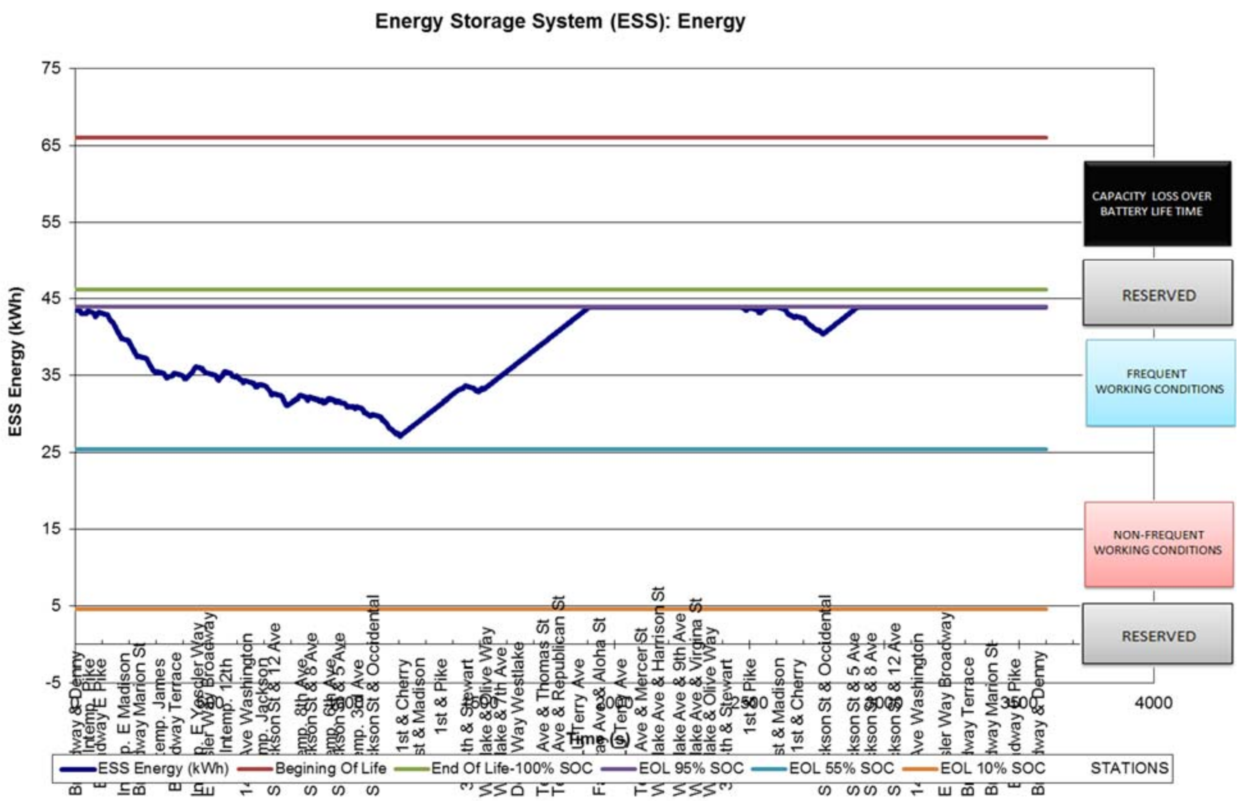


Figure 10. *OESS discharge diagram – Nominal case simulation*

The figure above shows the energy storage system capacity variation (state of charge) along the route under the conditions defined in the Technical Specification.

Once the catenary-free section is over (in the lowest point of the diagram), the OESS system starts charging again until the initial capacity is restored.

When the second catenary free section is reached the same procedure is applied again, the OESS system is discharged (just slightly due to the small amount of energy required) and once the catenary section is reached once more, the OESS system is again charged to its completion.

1.B.4.4 SIZING CONDITIONS FOR WORST CASE OPERATION

In order to ensure there will be enough energy in the OESS system in any scenario, so there is no risk of running out of energy and getting stuck en route, the equipment is sized to be able to operate according to the worst case conditions explained below:

- Streetcar configuration: C1-S-C2 (3 modules).
- Route: As defined in the alignment profile including stops due to traffic lights and crossings, according to the requirements of the technical specification.

- Performance curves as defined
- Load: AW3 (6 p/m^2)
- Rotary inertia: 6.87% tare.
- Gear-box ratio: 5.44
- Rated wheel diameter: 585 mm.
- Dwell time: 30 seconds
- Number of unexpected stops: sectional traffic lights and at all cross sections (20 seconds)
- Jerk: 2 m/s3.
- Total brake rate: 1.34 m/s2
- Simulation mode: All-Out maximum performance.
- Non-compensated (lateral) acceleration: 1 m/s2.
- Maximum average auxiliary power in the off wire section: 40 kW.

1.B.4.4.1 RESULTS

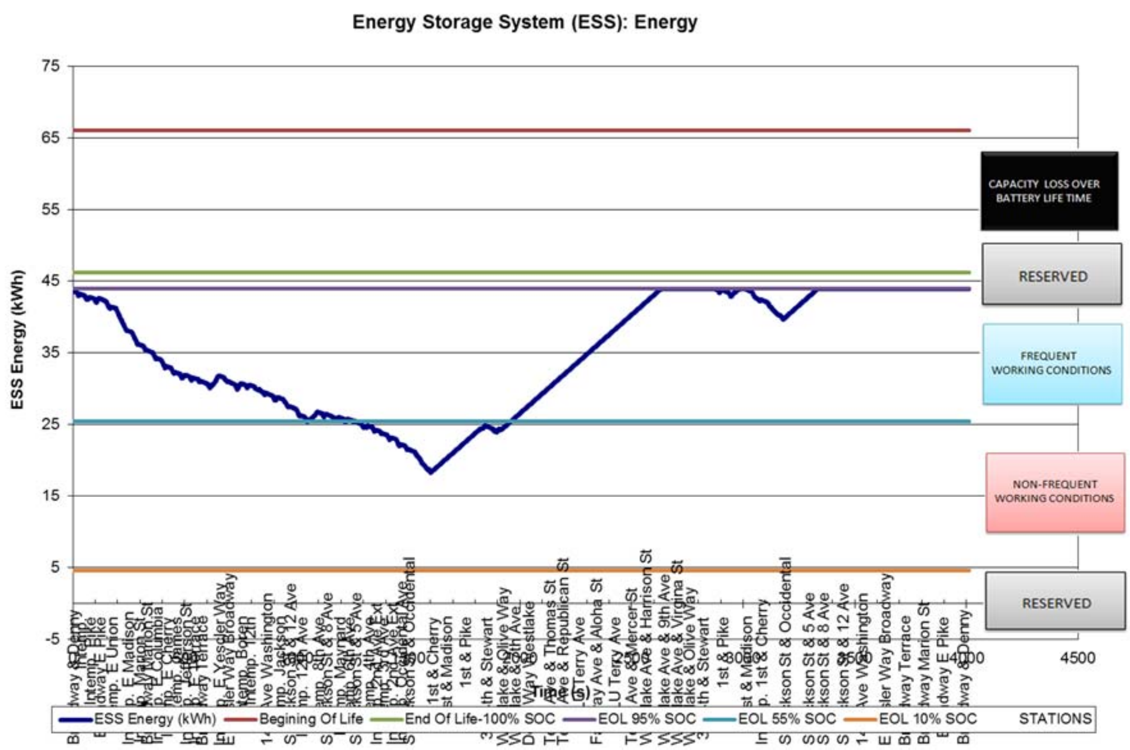


Figure 11. *OESS discharge diagram – Worst case simulation*

The figure above shows the energy storage system capacity variation (state of charge) along the route under the conditions defined for the worst case.

Once the catenary-free section is over (in the lowest point of the diagram), the OESS system starts charging again until the initial capacity is restored.

When the second catenary free section is reached the same procedure is applied again, the OESS system is discharged (just slightly due to the small amount of energy required) and once the catenary section is reached again, the OESS system is charged again to its completion.

1.B.4.5 PROTECTIVE MEASURES

1.B.4.5.1 ACTIVE BATTERY COOLING UNIT

In contrast to other energy storage technologies, lithium ion batteries are very sensitive to operating temperature, especially to cold and hot conditions. Thus, an active cooling system is included to ensure a long product life span.

Together with the active cooling unit, and to keep the batteries within a lower and upper temperature range, a liquid coolant is typically employed to either:

- Extract the heat from the battery and then exchange it with an active cooling circuit, consisting of a typical Carnot cycle, or
- Heat the liquid coolant when the ambient temperature is low.

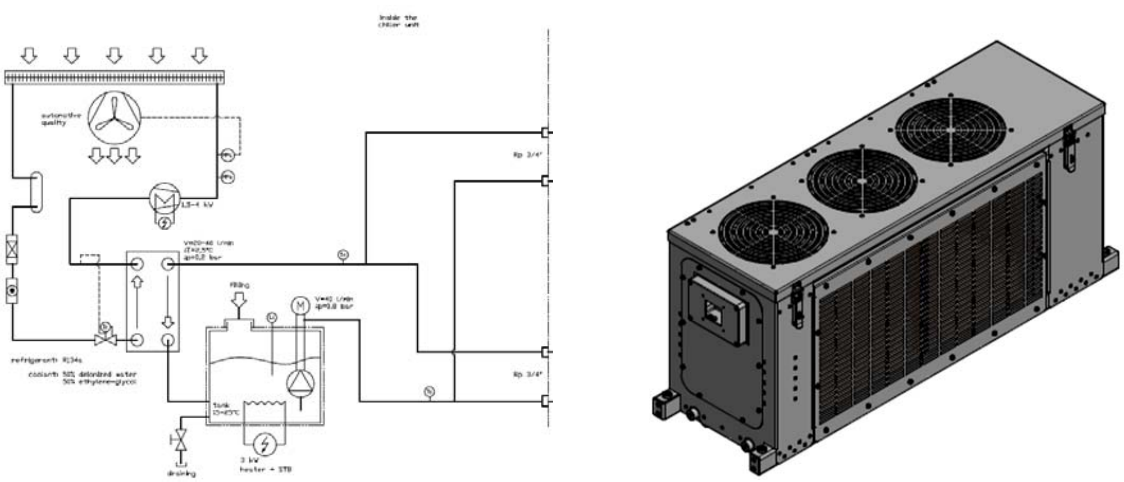


Figure 12. *Example of an active battery cooling unit ('chiller')*

1.B.4.5.2 ENERGY MANAGEMENT

To guarantee maximum efficiency and performance, the OESS system is controlled by advanced hybrid control algorithms.

The OESS deals with any unexpected situation, such as traffic jams or unscheduled stops. In those cases, the system automatically requests a reduction in performance to prevent energy deficits in a specific section.

The definition and adjustment of the preventive measures will be adjusted at project phase, after performing a more detailed study of the route and final design of the vehicle.

In addition to the automatic preventive measures from above, the overall status of the OESS system is also available to the driver from the HMI (state-of-charge, etc.).

1.B.4.5.3 REMOTE MONITORING AND DIAGNOSTIC SYSTEM

A remote monitoring and diagnosis system is employed over the life of the vehicle in order to advise the customer about usage and storage conditions. Additionally, the data acquired permits CAF P&A to continuously improve its energy storage solutions in line with the customers' requirements, keep the latest technologies available for future system upgrades.

1.B.5 POSSIBLE UPGRADES OF THE PROPOSED EQUIPMENT

The proposed equipment will be designed to be easily upgraded to meet future needs, and so can be upgraded to fulfill future energy requirements.

1.B.6 EMERGENCY SITUATIONS

The OESS system has been sized to comply with the requirements in the technical specification, which include:

- Consider stopping at every traffic light along the route.
- Consider 1 unexpected stop per section (20 seconds)
- Consider a 30 seconds stop at every station.

If a more severe situation occurs during operation, the OESS will continue powering the streetcar normally until energy is depleted. If that happens, an emergency battery is installed to power the emergency loads (a minimum amount of loads to keep the streetcar operable while in an emergency situation, like a long term catenary loss, traffic blockage for an extended period, etc.).

Please refer to section 9.A.2 of document Sub-part A, Section .9 Auxiliary Electrical Equipment for further information on the emergency loads.

1.C OFF WIRE TRACTION AND BRAKING PERFORMANCE

1.C.1 NORMAL PERFORMANCES WITH 0% SLOPE

1.C.1.1 CHARACTERISTICS

Traction and braking performance. Normal mode with 0% slope.	
Vehicle load for traction	AW 2 (4 p/m^2)
Maximum acceleration	1.34 m/s^2
Mean acceleration from 0 to 7.4 km/h (without Jerk)	1.33 m/s^2
Mean acceleration from 0 to 7.4 km/h (with Jerk)*	1.09 m/s^2
Residual acceleration at 70 km/h	0.05 m/s^2
Vehicle load for braking	AW 3 (6 p/m^2)
Maximum deceleration	1.34 m/s^2
Mean electrical deceleration from 50 to 0 km/h (without Jerk)	1.34 m/s^2
Mean electrical deceleration from 50 to 0 km/h (with Jerk)*	1.22 m/s^2
Traction rated voltage	750 Vdc
Braking rated voltage	900 Vdc

In the following sections, the traction and braking effort curves are shown. The values on the table above are obtained considering those traction and braking effort curves.

1.C.1.2 TRACTION

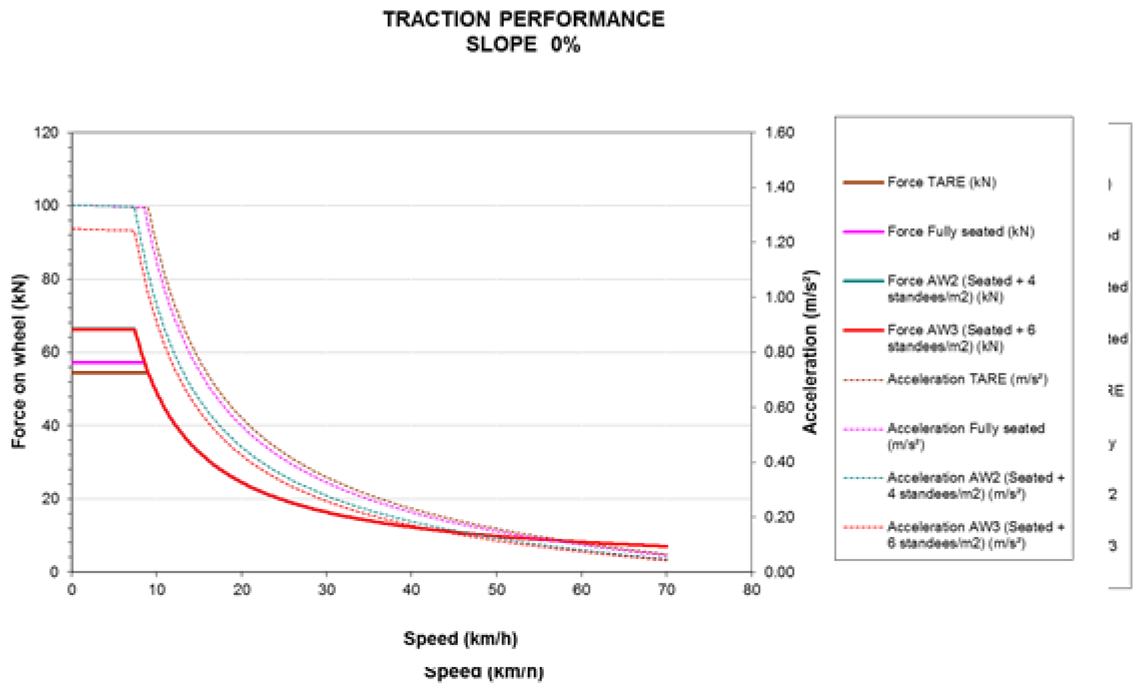
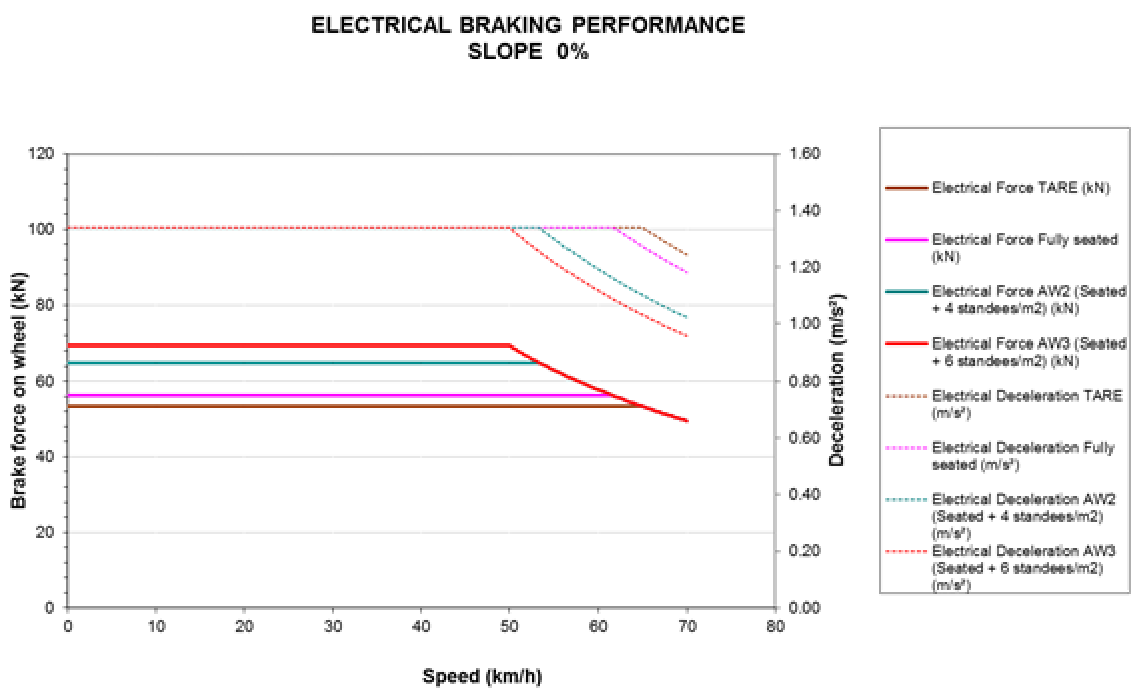


Figure 13. *Traction effort and acceleration curves for AW0, AW1, AW2, AW3 and AW4 loading conditions*

1.C.1.3 BRAKING



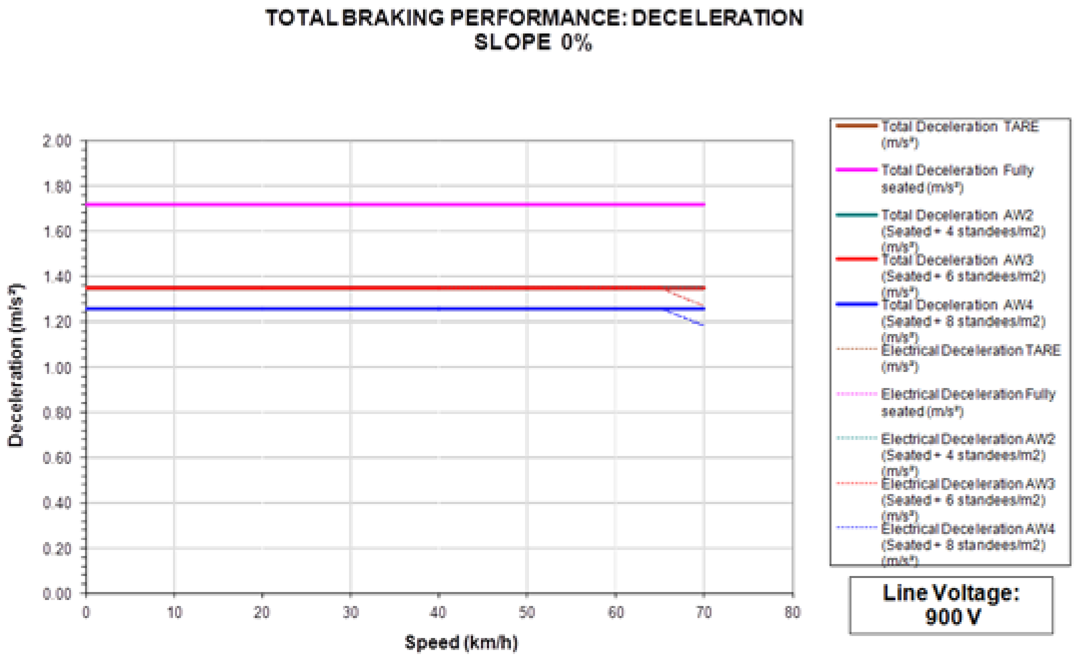


Figure 14. *Braking effort and deceleration curves for AW0, AW1, AW2, AW3 and AW4 loading conditions*

1.C.1.4 STARTING IN RAMP

The acceleration and balancing speed (top speed) for AW0 and AW3 loading conditions when starting in a 3% and 6% gradient is included below, as requested in the technical specification.

		Tangent track	3% uphill grade	6% uphill grade
AW0	**Speed (km/h)**	70	35	20
	Acceleration (m/s²)	1.34	1.06	0.79
AW3	**Speed (km/h)**	70	28	15.04
	Acceleration (m/s²)	1.25	0.97	0.69

Table 1. *Starting in ramp – Catenary free section*

1.C.2 ENERGY CONSUMPTION SIMULATION – OESS SECTIONS

1.C.2.1 TIMING AND ENERGY CONSUMPTION

These simulations are prepared in order to analyze the energy consumption of the streetcar along the Center City Connector route.

Find below the conditions used for the simulations:

- Streetcar configuration: C1-S- C2 (three (3) modules)
- Route: Please refer to section C.4.2 of this document
- Track speed limit: 48 km/h
  - Off-wire: 25 km/h
  - On-wire: 48 km/h
- Catenary voltage: 750V for traction and 900V for braking
- Load: AW2 (4p/m^2)
- Rotary inertia: 6.87% tare
- Gear-box ratio: 5.44
- Rated wheel diameter: 585 mm
- Jerk: 2 m/s^3
- Total brake: 1.34 m/s^2
- Simulation mode: All-Out -maximum performance-
- Non-compensated (lateral) acceleration: 1 m/s^2
- Stations dwell time: 30 secs.
- Unexpected stops: all cross streets (20 secs).
- Considered auxiliary power: 30 kW

The conditions hereby described correspond to quite demanding operating conditions, higher than the ones defined for nominal case operation, resulting this simulation out of the 90% of the operating cases.

The simulation results, including the route wireless segment time (in seconds) and the energy consumed in that segment are shown below.

Wireless Segments	TIME	Energy consumption (traction + auxiliary)
Broadway and Denny to South Jackson and Occidental Stations	1430.3 sg	31.5 kWh
Jackson and Occidental Stations to First and Cherry Stations	77.8 sg	2.85 kWh
Stewart and 2nd to Westlake and 6th Stations	85.9 sg	1.1 kWh
Stewart and 2nd to Jackson and Occidental Stations	273 sg	4.95 kWh

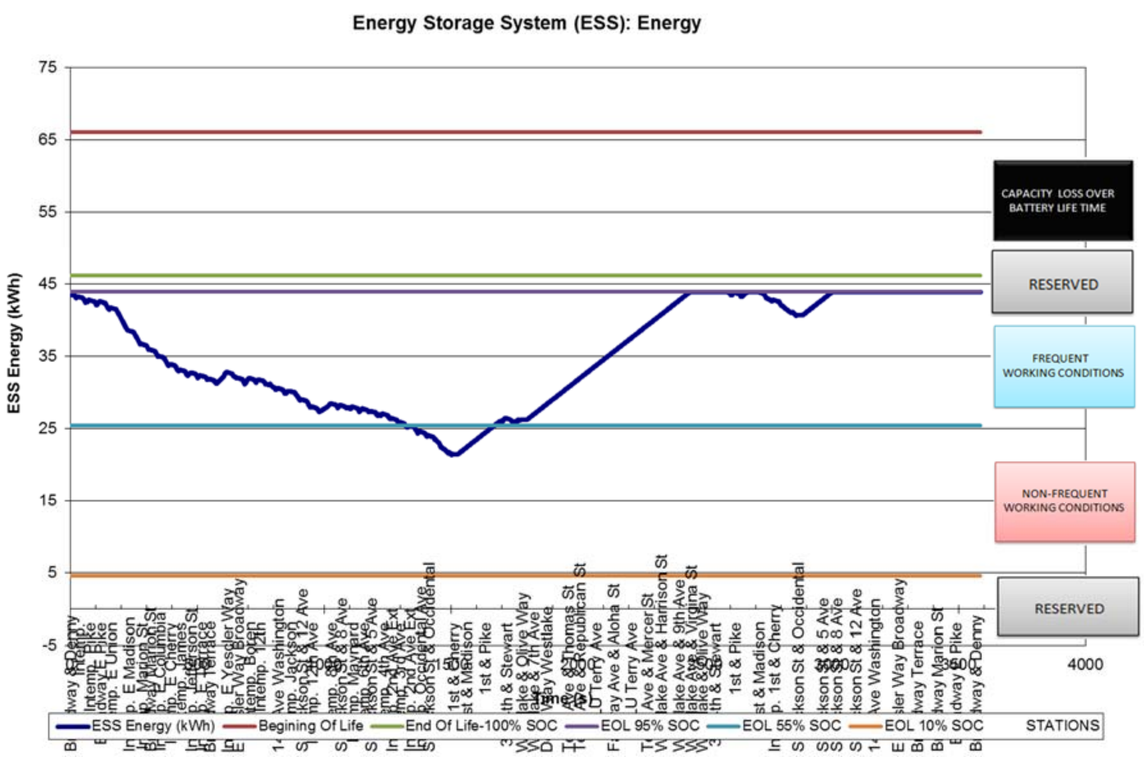


Figure 15. *OESS discharge diagram – Energy consumption simulation*

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Sub-Part C – MANAGEMENT APPROACH AND SCHEDULE

Sub-Part C – MANAGEMENT APPROACH AND SCHEDULE

SECTION A PROGRAM CONTROL AND QUALITY ASSURANCE

CAF's main objective is to supply reliable vehicles and services on time in compliance with the Technical Specification. To help achieve this objective, CAF maintains a comprehensive Project Management System which plans, coordinates, and controls the activities throughout the project.

For the management of this Project, CAF will develop a project specific Project Management (PM) Plan. This plan will define all activities, stages, processes, resources, responsibilities, etc., that will be used in order to deliver a vehicle that fully complies with the City's functional requirements and schedule.

The core Project Management team consists of the Program Manager, the Lead Project Engineer, the Scheduling Engineer, the Production Manager and the Project QA Manager. Other key departments participating on this team will be: Purchasing, RAMS (Reliability, Availability, Maintainability and Safety), Testing and Commissioning, and Warranty.

The Program Manager is the single person responsible for the program both internally and externally. The Program Manager, following established procedures, will manage all communications within CAF and with SDOT, as the single point of contact.

The Scheduling Engineer from the Planning Department has a key role being responsible for (1) developing the project schedule and (2) tracking project activities against the schedule.

The Project Management team will be introduced to the organization at the Kick-off meeting, which will take place shortly after award. At this meeting, all communications protocols and meeting schedules will be established. If awarded, CAF's Program Management Plan will be submitted within 30 days of NTP. To illustrate our Program Management oversight throughout the project, we have included the following flowchart, detailing the different phases of CAF's Project Management Plan.

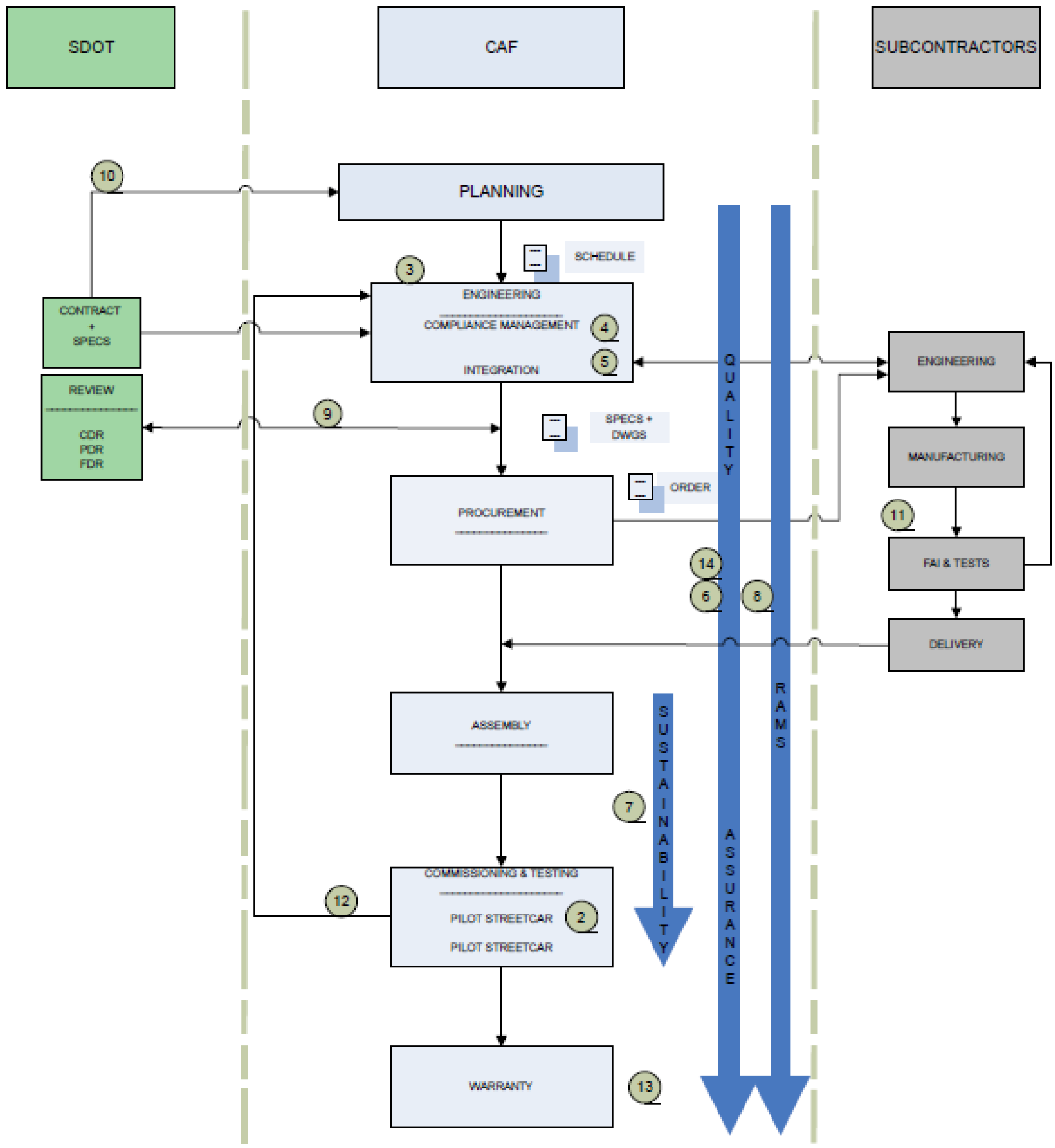


Figure 1. PM Plan Flowchart

1.A. DESIGN PLANNING, QUALITY ASSURANCE AND WORK FLOW

This section provides the requested information regarding CAF's design location(s), design controls, system integration, quality assurance, and design feedback, which is graphically represented in two flow charts within this document.

1.A.1. LOCATION

The integral design of the vehicle will take place in Spain with support from Elmira, NY.

1.A.2. TEAM

The Engineering Department supported by the R&D Department will design the vehicles for this Project. CAF will provide a fully experienced and multidisciplinary Project Design Team to ensure fulfillment of SDOT's Technical Specifications requirement. All proposed key personnel have worked in similar projects before and have many years of experience in streetcar and light rail vehicle design. The multidisciplinary team approach enables all technical aspects of the design to be addressed.

The Engineering Department develops its work based in a project matrix organization structured in two dimensions:

- Technical Specialties (TS), responsible for design activities.
- Lead Project Engineers, responsible for managing TS to satisfy SDOT's requirements.

For each project, the Technical Director appoints a Lead Project Engineer who has the responsibility to manage the design work of the engineers from the different TS assigned to that project. The matrix organization ensures effective communication within CAF, efficient status feedback, and timely action. The figure below shows the Design Team organization for a previous streetcar project.

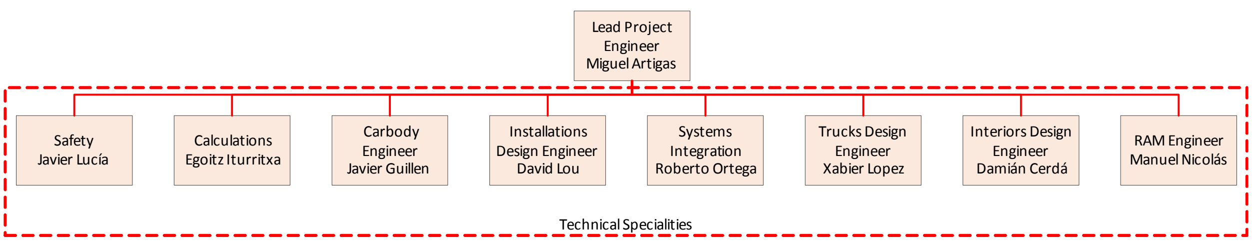


Figure 2. Design Team Structure

The Engineering portion of the Organizational Chart in I. Staffing Plans and Résumés shows the structure of the Engineering and Technology departments and the reporting lines for the members of the Design Team within the organization.

Please note that RAM Department and Safety Department are separate, and not part of Engineering Department, as CAF understands that RAM and Safety requirements have to be managed independently.

1.A.3. DESIGN TOOLS

The Engineering Department utilizes state of the art hardware and software resources, such as:

- CATIA CAD: 96 workstations. 10 more in the shops for jig design, nesting and manufacturing.
- ABAQUS Finite Element Analysis: 6 Workstations.
- Dynamic Simulation Code (SIDIVE) for Stability, Ride Performance, Parameter
- Optimization and Curve Negotiations.

1.B. DESIGN CONTROL

The Design Flowchart is shown below. The numbered events/processes are referenced throughout this document (denoted by highlighted numbers in parentheses)

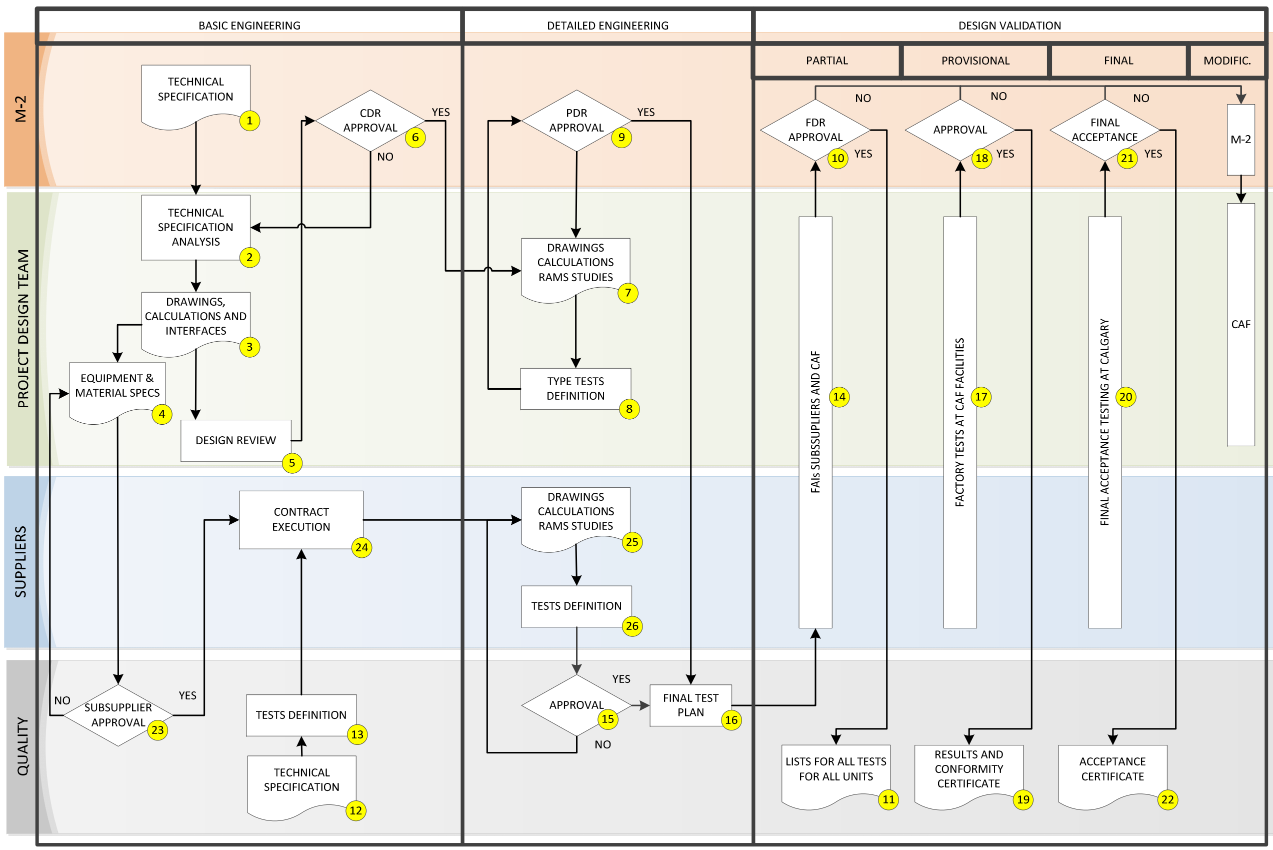


Figure 3. Design Flow Chart

1.B.1. SPECIFICATION REQUIREMENTS

The first step in the design definition process is a preliminary review and analysis of the contractual requirements, along with the initial planning for the controls and verifications of the design.

The main inputs to the design work will be SDOT's Specifications (1), the established standards, and CAF technical know-how. During the design phase:

- The Technical Specification is updated

  The Lead Project Engineer will incorporate all change orders to the Technical Specification and will ensure that all internal departments and subcontractors are working with the most recent configuration.

- The Requirements of Technical Specification are met

  In order to ensure that the requirements of the Technical Specification are met, for each project, CAF's Engineering Department designates a specific Design Review Group. The Lead Design Engineer, representatives from all technical departments, Quality Assurance and Manufacturing will form the Design Review Group for this project. The group will consist of 7 to 10 individuals from CAF, in addition to the eventual SDOT or subcontractor representatives. The design reviews will be carried out internally and externally with SDOT and Subcontractors.

  The main purpose of the design reviews is to check that the design complies with the requirements of the Technical Specification, to discuss identified alternatives, to clarify the requirements and to make decisions about the evolution of the design.

- The Design Review comments are fed back into the design process

  To ensure that the comments are fed back into the design process, the minutes of the Design Review meetings are used to record the review and actions to be carried out. The conclusions of the meetings are fed back into the design process by modifying or adding drawings and/or test procedures, indicating the need for additional calculations or tests, recommending engineering change requests, recommending Technical Specification formal changes, etc.

The Lead Project Engineer completes a preliminary analysis of all available documentation, and presents the project to the Project Design Team, the RAM Manager, and Managers of the appropriate technical areas.

The Lead Project Engineer creates the Project Product Structure in the Engineering Data Base (EDB) for the particular Project. All technical documentation for the Project is organized and maintained in this data base.

The Project Design Team review and analyze (2) the specifications and the preliminary design to ensure compliance with the Contract requirements. Documents reviewed include:

- The applicable contractual technical requirements.
- Reliability, Availability, Maintainability and Safety (RAMS) requirements, in addition to contractual RAMS requirements, if any.

- Environmental aspects applicable to the project, and the actions to be taken in the design development in relation to these aspects.
- Critical aspects relating to welding: Applicable codes and standards, regulatory and statutory requirements, and the capacity to fulfill the prescribed requirements.
- Interchangeability requirements, if applicable.

Once the baseline documents are analyzed, the first version of the Requirements Data Base (BERDE) is generated, containing all the contractual technical requirements. This Requirements Data Base will be the main tool to manage and monitor each single requirement, its status, responsible, required tests, closing date, etc. as can be seen throughout this document.

1.B.2. DESIGN AND SYSTEM INTEGRATION

The design is planned by the Lead Project Engineer and executed by following a process to systematically analyze all the data that affects the product to be designed.

Each contractual requirement, including functionality, reliability, maintainability, safety, interchangeability requirements, and long-term spare parts provisioning, is analyzed. Various design hypotheses and alternatives are considered, and the final solution approved and verified. During all design development stages, the contractual requirements are embedded in the design documentation and tracked.

To optimize product design and manufacturability, specialists from various departments collaborate with the Design Team during different design phases. The features and requirements needed to optimize the product design, the production process and, subsequently, spare parts management, are considered from the production conception stage. Concurrent Engineering meetings are conducted and attended by the different departments as necessary.

During the development phase, BERDE will be updated by the Lead Project Engineer and members of the Design Team; including any new requirements, removing those that no longer apply, or changing the status of the existing ones as a result of design reviews, verifications and validations.

Design development consists of the following stages: Basic Engineering, Detailed Engineering, and Design Verification through Testing and Validation.

Basic Engineering

Basic Engineering represents the formalization of the general design concept established during the proposal process. This stage will establish the first conceptual drawings, interfaces (3) and calculations of the design.

First, the Lead Project Engineer provides the Design Team with the basic engineering/preliminary design information needed for the design effort. The Lead Project Engineer also keeps the Design Team informed of any changes to the Specification.

The following activities, among others, are accomplished during the Basic Engineering:

- Definition of the drawings of the main assemblies.
- Establishment of the general rules and layouts.
- Creation of the lists and specifications (4) of the Major Outsourced Items (MSI).

- Execution of the first calculation of gauge clearance, curve negotiation, vehicle performance and required electric power.
- Creation of RAMS plans and/or studies corresponding to each phase.
- Creation of ICS, EMC plans etc. as is applicable to the project.
- Creating the Preliminary Spare Parts list.

During this period CAF will continuously inform SDOT about the design progress. Some issues will require input by SDOT to support the basic engineering process.

The Lead Design Engineer will manage the Design Review Group in order to review (5) and monitor the progress of the design. The group will discuss the alternatives in order to clarify the requirements and to make design decisions.

During this stage, CAF will conduct collaborative Conceptual Design Review (CDR) (6) meetings with SDOT to present the conceptual design and to identify interface requirements. All activities are documented in the Design meeting minutes.

Detailed Engineering

Following the previous phase and incorporating all inputs received in design reviews (both internally and externally), the Design Team will create the detailed design (7) documentation based on the basic engineering documents. The documents will include:

- Calculations.
- RAM and Safety studies related to this phase.
- Specifications and various studies (ergonomic, EMC, as applicable).
- Fire Prevention Safety project, as applicable.
- Test and trials list and protocols (8)
- Train control software.
- Wiring database.
- Training documentation.
- Maintenance Documentation.

This documentation establishes the essential characteristics for the safe and appropriate operation of the vehicle, as well as fulfillment of all specification requirements.

These documents are subject to revisions, based on the outcome of design phases, PDR (Preliminary Design Review) (9) and FDR (Final Design Review) (10).

The FDR will be conducted at the end of each sub-system design and will confirm that the design meets the Technical Specifications. The Final Design Review will provide the opportunity to agree on the final drawings prior to release of the design and will include finalized submittals of all required drawings and documentation, including the lists for all tests for all units (11).

When very specific design processes needs to be carried out, the Technological Areas are supported by specialists from those areas (fire, extreme climatic conditions, ergonomics, dynamic simulations, etc.). The Lead Project Engineer will create teams of joint experience in vehicle design and specialist staff for these specific technical areas.

During the entire design execution process (see Figure 3 Design Flowchart), SDOT will play an essential role; participating in the design, reviewing the design and accepting the final design.

Design Documentation

The drawings and their associated documentation will define the configuration of any part, component or assembly. The Lead Project Engineer will coordinate the preparation of the technical documents to be sent to SDOT, in accordance with the contract requirements.

The Project Manager will be responsible for submitting all the documentation to SDOT, according to the agreed scope, format, delivery schedule, content, standards, etc.

The Project Management office will maintain a record of drawing and document status, including document number, revision letter, title, date, transmittal document, disposition, and the document number identifying the disposition. The record will be updated monthly and submitted to SDOT.

Work Breakdown Structure (WBS)

Based on the drawings received from Lead Project Engineer, the Process Department will establish the work breakdown structure (or production structure), which will be distributed to the production engineers. BaaN, the ERP used by CAF will be utilized to generate the corresponding procurement and production orders, based on the production plans and the work breakdown structure.

1.B.3. DESIGN VERIFICATION

Design verification is the process of obtaining SDOT's formal acceptance and approval of the completed project scope and associated deliverables. The scope of the contract will be verified in different phases throughout the project:

1. Partial verifications during the design, supply and production/assembly stages
2. Verifications to obtain provisional approval for the vehicles
3. Verifications to obtain final approval for the vehicles

Partial Verifications

Three types of design verifications normally exist:

- verification of the design concept (CDR)
- verification of the detailed design (PDR)
- final partial verification of design (FDR)

Before any of these verification processes are submitted to SDOT, drawings, specifications and any other necessary documents will be sent to SDOT with sufficient time allowed for review so that it can be performed correctly.

Regarding verifications of outsourced items, the characteristics to be verified will be identified by the corresponding manager of the appropriate Technical Specialty. For critical vehicle systems such as, propulsion, brakes, HVAC, APS, etc., this process will be carried out in close collaboration with the supplier.

Using the design requirements (12) as a basis, the Project Quality Manager will establish the FAI plan and type tests (13) to be performed. This plan will be presented to SDOT so they can decide at which FAIs and tests they would like to be present.

Similarly, with reference to products to be manufactured/assembled by CAF, the Design Team will set out the characteristics of those products that should be verified and Quality will create the corresponding verification plan. This will be presented to SDOT so that they can arrange participation in any activities that they consider necessary.

Validation for both FAIs for outsourced items and products manufactured/assembled by CAF will be validated (14) following the Final Test Plan approved by SDOT.

The conclusions drawn from these reviews will be included in the corresponding minutes of the meeting to ensure that the action is taken.

Verification to obtain Provisional Approval

During the design stage, the Lead Project Engineer will develop the list of trials and type tests (8) to be carried out, based on contractual requirements, as well as requirements that derive from specifications or applicable standards, with participation of CAF's Quality and Testing departments.

The tests at CAF's factory and on the track will include Major Subcontracted Items (MSIs). Using the list of trials and type tests, the Project Quality Manager will develop the list of series tests to be carried out on all the units (11).

Personnel from the appropriate Technical Specialty (TS) will develop the testing protocols, which will be approved by the Lead Project Engineer. Any final tests to be performed on equipment supplied by SDOT shall be performed in accordance with protocols established by the equipment supplier and SDOT.

Using the lists and protocols for trials and tests, the Project Quality Manager will develop the plan for final tests, which will be presented to SDOT for approval (15). Once approved by SDOT, the Final Test Plan (16) will be established defining i) Final Tests to be performed ii) Testing Protocols iii) Quality Records to be established iv) Type or Serial Test and frequency (inspection level) and v) Points of action by SDOT or their representatives.

a) Factory Tests execution

Personnel from CAF's testing department and, if applicable, personnel from the relevant suppliers, will perform the trials and tests (17) that have been established. The results will be recorded on the respective forms. The department responsible will review the results obtained before dating and signing them.

Representatives from the Design Team and the Quality Manager will be present while the trials and final type tests are performed, along with SDOT representatives, if this has been agreed in advance. The records of the results will be delivered to the Quality department, who will approve, sign, date and file them.

The Project Quality Manager or head of the quality department will draw up the results of performed tests that will be submitted to SDOT for approval (18). If approved, the Quality Manager will submit the Conformity Certificate (19), including their signature and the signature of SDOT's representative, if applicable, and any SDOT comments or reservations.

b) Track Testing execution

Track tests will be performed (20) by personnel from the testing department in the presence of a manager from CAF's Quality Department or an authorized representative. They will be assisted by the Project Manager to coordinate the presence of SDOT and/or Lead Project Engineer during the tests.

The results obtained from the type and series tests will be recorded and signed by the CAF representative and SDOT representative, if applicable. The records will be reviewed by Quality before they are transmitted to the Project Manager, who will update the status of any pending issues and customer reservations.

If there are any pending issues or SDOT reservations, the Project Manager will work with all departments involved, as well as after-sales service and maintenance, to draw up the corresponding action plan. This plan will list the people responsible and the implementation dates for said actions.

For each unit, the Quality department will prepare a complete file consisting of the record sheets of the results from the production checks, final trials and tests (type or series) and the Certificate of Conformity; in general, the documents defined in the Inspection and Tests Plan relating to the Project.

Final Approval

After SDOT accepts the delivery of the vehicle, CAF's Rail Services (RSS) will be responsible for closing any points that are pending resolution, and for ensuring that the contractual conditions of availability, reliability and any other areas are complied with so that it can be finally approved.

When these conditions are met, SDOT will be requested to finally accept the vehicles (21). This will be reflected in the corresponding Acceptance Certificate (22) document.

1.B.4. SYSTEM INTEGRATION

Design work will be accomplished by the Design Team consisting of engineers (technical specialties) from several disciplines. The Lead Project Engineer will manage and lead the team of engineers from Systems (Propulsion, HVAC, Brakes, Energy Storage System, etc.), Carbody Structure, Installations Design, Trucks and Interior Design. This team will also be assisted by designers, draftsmen, calculators and miscellaneous support staff.

In order to control the design of the systems not manufactured by CAF (i.e. propulsion equipment, brake equipment, HVAC, communications), the Systems Engineers (part of the Design Team) will be fully dedicated to supervising the performance of the system subcontractors and system integration.

The Design Team organization, and the system integration procedure detailed below, has been successfully applied on many previous projects, including but not limited to Cincinnati and Kansas City Streetcar Projects. It guarantees that all the design work (including subcontractor design work) is performed in a timely manner and in full compliance with the Technical Specifications.

CAF is the Systems Integrator, and will be responsible for the proper interrelation, functioning, and system integration of all phases of all vehicle systems and their interrelations with all other parts of the vehicle, maintenance shops and equipment, and the total transit system, including train control.

Pre-Contract Award Phase

Systems Engineers will report directly to the Lead Project Engineer who will be in charge of coordinating the engineers from the different technical specialties within the Design Team.

During the Pre-Contract Award Phase, SDOT Technical Specification, including all the issued Addenda, will be analyzed by every Systems Engineer. They will study requirements in the Technical Specification focusing in aspects such as, but not limited to, EMI, Noise, Reliability and Maintainability.

One of the first aspects to be studied will be the compatibility with the system and the material requirements. Once these preliminary analyses have been completed, the Systems Engineers will identify the following equipment requirements (4): Functional requirements, Design specification, Electrical interfaces, Installation, Mechanical interfaces, Materials to be used, Maintenance requirements, Accessibility, Reliability requirements, Safety requirements, Testing.

In order to establish the interface strategy, CAF, along with SDOT input, will define the MDS interface, the interface with other systems and the car-wiring interface.

During this phase, the Systems Engineers, along with the Purchasing Department, will begin the selection process of subcontractors for each system. According to CAF's Quality Standards, all subcontractors must be approved (23) by QA Department (following an internal procedure available upon request) in order to place any order by Purchasing Department.

The most critical task of this phase will be the preparation of the Technical Procurement Specification (TPS) for each of the major systems. This document will include Technical Requirements, Installation Requirements, Documentation Requirements, Reporting Requirements, Vehicle Drawings and Additional Interface Documents.

In addition to the TPS, the Purchasing Department will prepare the General Conditions (i.e. milestones, design approval process) and the Contract model between CAF and the potential subcontractor. The contract will include commercial requirements, such as prices and method of payment, warranty, rail services, quality assurance program, spare parts, bench testers and special tools, user education, penalties, rights in technical data, etc.

All documents in the major systems procurement will include all applicable requirements of SDOT's Technical Specification.

The TPS document will be sent to all suppliers, who will each respond with a proposal. Once those proposals have been received, Systems Engineers will conduct a technical evaluation of the received proposal. Project Management and Procurement Management will then review this technical evaluation

The final subcontractors will be selected by the Purchasing Department together with the Systems Engineers, then the contract will be executed (24). The decision will be made taking into account factors such as; technical characteristics from either SDOT or internal, price, experience with previous projects and service-proven design and references. If, during the subcontractor selection or after design reviews, the requirements for the systems are modified, such modifications will be included in the Technical Procurement Specifications, which will be updated as required.

Design Phase

The Design Phase will begin with the award of each system to the respective subcontractor. The design for each system will be closely monitored by the Systems Engineers, who will analyze all

design phase documentation (drawings, calculations, RAMS, etc.) (25) submitted by the subcontractors. The Technical Procurement Specifications and the Contract will include precise requirements such as the design schedule, the required design reviews and meetings, and engineering deliverables, in order to guarantee the efficient subcontractor design work.

The main design tool used for this purpose will be the Interface Document. This document will compile all the technical information required to install equipment components (main dimensions, location of brackets or supports, weight and center of gravity, pneumatic or hydraulic connections, absorbed maximum currents, detailed information of all connectors and their pins, inputs and outputs, etc.), and will ensure that the equipment is properly integrated. This document will provide a reference for the definition of CAF circuit diagrams and wiring information and will assist in the definition of the interface among the systems on the vehicle.

This document will be a 'living document', meaning that it will be continuously updated as required during the design phase. Updating the Interface Document will guarantee that any configuration or design revisions (either proposed by SDOT, the subcontractor, CAF Systems Engineers or CAF manufacturing divisions) will be taken into account in the design of the equipment. The Interface Document will be prepared and kept up to date by the systems subcontractor and approved by the Systems Engineer responsible for the equipment.

Systems Engineers supervision of subcontractor work will extend through all project phases, including design, manufacturing, design conformance and production conformance testing, commissioning and warranty period. All changes which affect system design will be approved by the System Engineer responsible for that particular system.

During this phase, CDRLs according to the requirements of the Technical Specification, will be created and submitted to SDOT.

Manufacturing and Testing Phase

CAF understands that for smooth, seamless systems integration, the Design and Quality Assurance Departments will need to coordinate proactively the different production phases, in order to guide the manufacturing engineers and the labor force. The most critical stage is the Manufacturing of the Pilot Cars, since it is at this initial phase, difficulties in the manufacturing process are most likely to be detected. The experience acquired and any lessons learned during the manufacturing of the Pilot Cars will be applied to the manufacture of the remaining vehicles.

The Testing process will be the same as the manufacturing process. The Systems Engineers, together with the Quality Assurance Department, will create the conformance and acceptance testing plan and procedures. The Pilot Cars will be tested first; if any updates are to be done to the other vehicles, they will be performed according to the Technical Specification.

1.C. QUALITY ASSURANCE OF THE DESIGN

The Project Quality Assurance Program Plan describes the planning of Design and Development activities in CAF. These plans are subject to monitoring and updating as the design develops.

It is CAF’s standard procedure to perform periodic in-progress reviews. The following reviews will be conducted: Conceptual Design Review (CDR), Preliminary Design Review (PDR) and Final Design Review (FDR). The objective of this process is to capitalize on the expertise of CAF’s staff and obtain input and feedback from their previous manufacturing experiences to ensure that all customer expectations and requirements are met.

In addition to this main objective, the design reviews may also target i) the compatibility among assemblies, items and systems, as well as functional and physical interactions between items ii) the strength of the design against variability of processes iii) the criticality of the product and its effect on failures and regarding safety and iv) the internal CAF requirements: Special processes, environmental aspects, RAMS, previous design feedback, etc.

These items may be added on the BERDE, or may be reviewed separately, depending on the scope of the points to be reviewed and depending on the Project Manager's criterion.

Design reviews are carried out in three phases as shown in Figure 4 below:

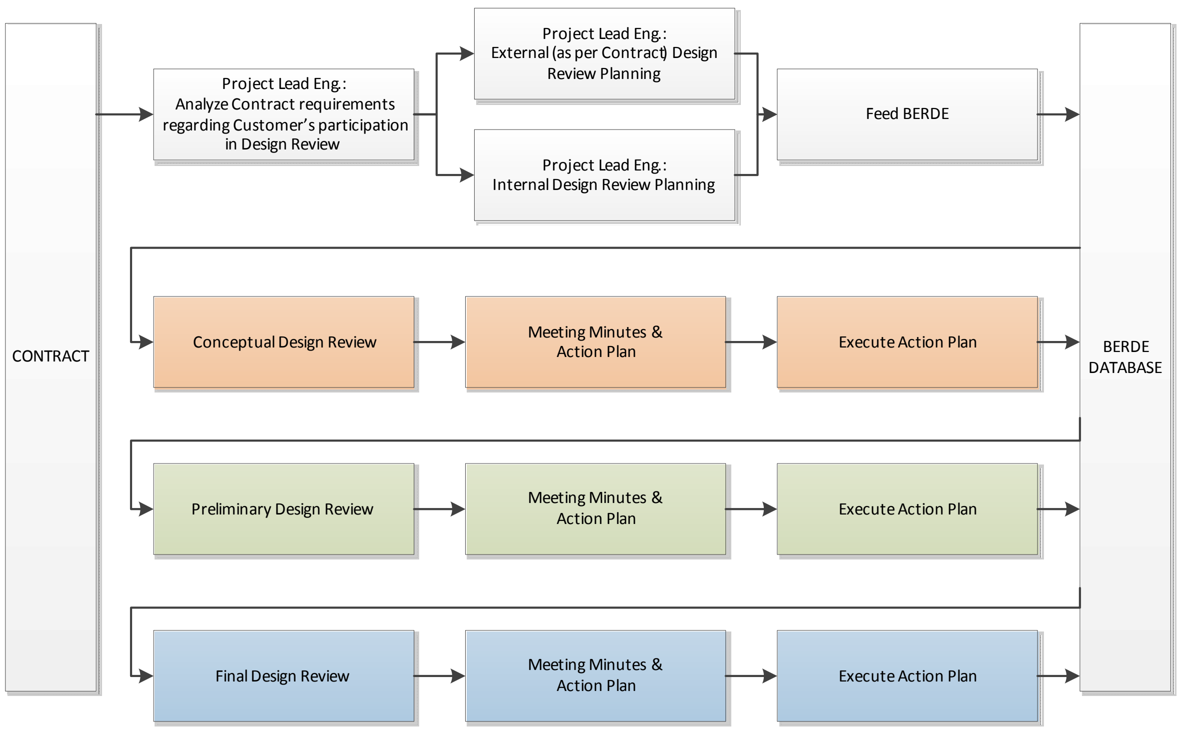


Figure 4. Design Team Structure

1.C.1. CONCEPTUAL DESIGN REVIEW

The conceptual design review will be carried out during the initial Project phase, once the Requirements Database is established (BERDE), following CAF's internal procedure P-05.02-BZ "Design Development". It is held once the Basic Engineering has been finished. In the conceptual design revision, those requirements that are indicated on the BERDE will be reviewed.

This revision is convened and managed by the Lead Project Engineer. The result of the design revisions will be documented in meeting minutes. Furthermore, and depending on the project complexity and the Lead Project Engineer's criteria, references to these minutes may be included on the BERDE, in order to ensure that there is a record of the corresponding revision and it is traceable to the requirements.

If as a result of this revision, the schedule of compliance with any of the analyzed requirements is modified, this will also be documented in the BERDE.

1.C.2. PRELIMINARY DESIGN REVIEW

The preliminary design review will be carried out during the main phase of the Detailed Engineering. As for the conceptual design revision, those requirements indicated on the BERDE will be reviewed.

This revision is convened and led by the Lead Project Engineer or by members of the Design Team in the corresponding field. The result of the design revisions will be documented in meeting minutes. Depending on the project complexity and the Lead Project Engineer's criterion, references to these minutes may be included in BERDE, in order to ensure a record of the corresponding revision that is traceable to the requirements.

If as a result of this revision the schedule of compliance with any of the analyzed requirements is modified, then this will also documented in BERDE.

1.C.3. FINAL DESIGN REVIEW

This is the last phase of the design revision, where the results of the previous design revisions will be confirmed. The final design revision takes place at the finalization of the last 3D or significant document that make up the design stage.

This revision is convened and led by the Lead Project Engineer or by members of the Design Team in the corresponding field. The result of the design revisions will be documented in meeting minutes. Depending on the project complexity and the Lead Project Engineer’s criterion, references to these minutes may be included in BERDE, in order to ensure a record of the corresponding revision that is traceable to the requirements.

If as a result of this revision the schedule of compliance with any of the analyzed requirements is modified, then this will also documented in BERDE.

1.D. MODIFICATIONS

Any CAF department may propose modifications aimed at resolving design non-conformities or propose improvements to processes or products.

All changes are subjected, prior to their launch and implementation, to a technical review and approval by the Design Team and to an impact evaluation and eventual approval by the Project Team. Customer is consulted when appropriate or as agreed upon. CAF maintains a full traceability of design changes and continuous monitoring of their actual implementation status.

Any modification is identified with a modification number and a project code, and, by default, is associated to a Design Review Group at Engineering Department. Depending on the origin of the change, CAF distinguishes two groups of modifications: the ones raised by CAF and the ones raised by SDOT.

The Modification Flowchart in Figure 5 provides a graphical illustration of the process, which is described in this section.

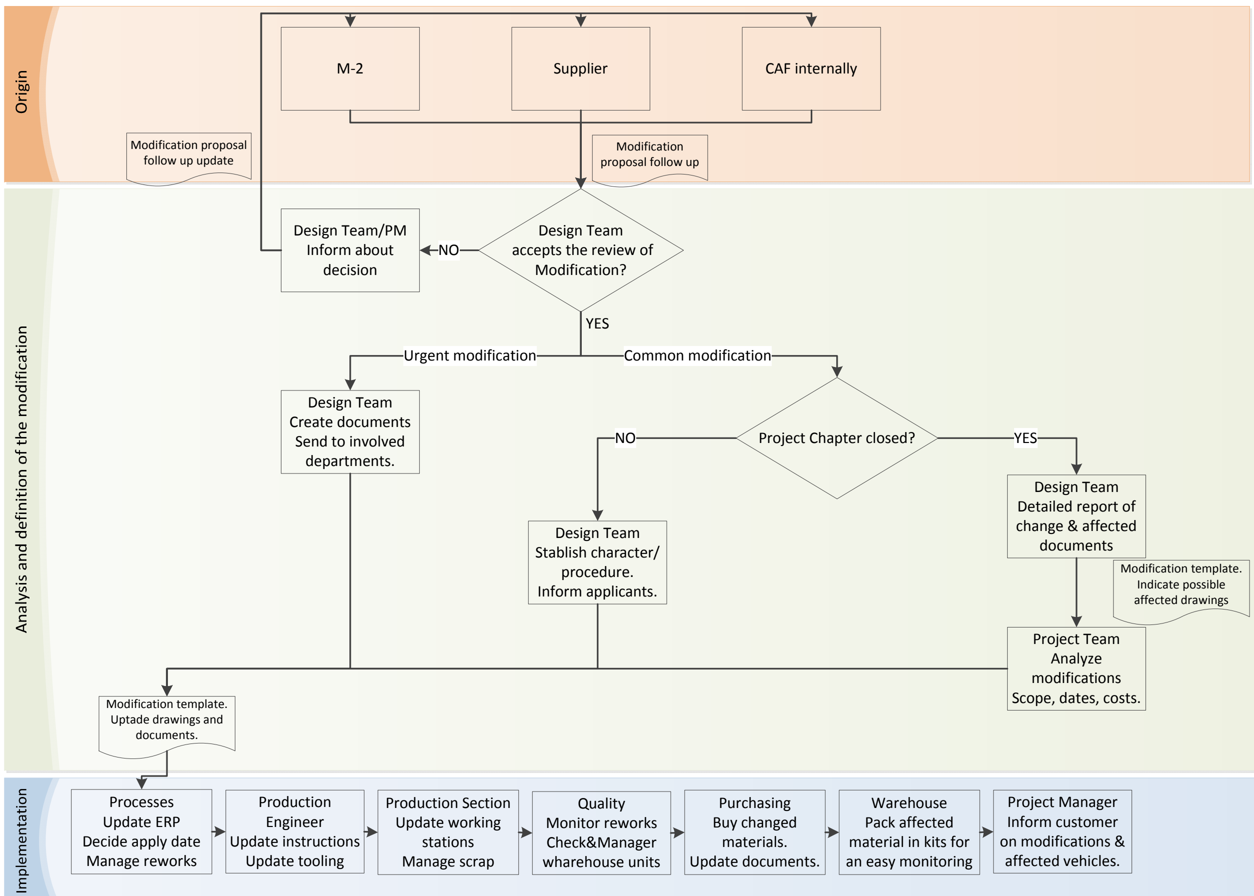


Figure 5. Modifications Flow Chart

1.D.1. MODIFICATIONS RAISED BY CAF

Any CAF Department can propose a drawing modification in order to avoid a design non-conformity or to improve products and processes. Any request will be communicated to the Design Team (DT) for its acceptance. The solicitants can inform the DT in the meetings held during the project or by completing the 'Modification Proposal Follow up Document.

If DT turns down the modification proposal, the requesting party is informed by them of the reasons for rejection. This information is registered in 'Modification Proposal Follow Up Document' and distributed via internal computer network.

If the proposal is accepted for review, DT personnel complete the 'Modification Template' in the network. The template should indicate drawings which could be initially affected. After this template, the Project Team will decide whether or not to continue with the implementation. An urgency procedure is available for special issues, as indicated in the flowchart.

The Project Team will analyze the modifications, define the scope, see work progress status of involved parts (support from Manufacturing Sections), review dates and costs and finally decide if it is to be implemented or not. It is also decided on which vehicle the modification is to be introduced and whether it is applicable to vehicles already delivered to the Customer or if alternative solutions are required for vehicles already built.

The approval of the modification is always under the purview of the Project Team before issuing of the modification. The updated drawings are marked with the new issue level and the nature of the modification is indicated.

Distribution and Implementation of Modification

The Process Department reviews the scope and application of the modification. It decides the first vehicle from which the modification is implemented and updates the ERP as appropriate.

The Production Engineering Departments review the modification and proceed to update the affected Production Dossier, documentation and tooling changing the issue code.

The Managers of the Production Sections update the drawings and documentation of the appropriate working stations points according to the appropriate procedures. They proceed with the rework or segregation of the affected material, inform Quality personnel of it.

The Quality personnel monitor the process and verify that documentation updates have been correctly completed.

The Purchasing department, based on the Quality department's procedure, updates the documentation to be sent to suppliers, then sends the new documentation to suppliers and raises new purchasing orders.

To facilitate the identification and dispatch control of materials, Warehouse compiles and packs all the material affected in a 'kit' form by modification number.

The Project Manager will inform on established modifications and the vehicles on which they have been applied in all modifications submitted to the Customer's approval.

1.D.2. MODIFICATIONS RAISED BY SDOT

If SDOT requests a modification, the Technical Project Engineer (after consultation with the Project Manager) and the affected Sections, including the After-Sales Department, review the proposed modification. Once the modification is analyzed, the Project Manager will inform SDOT about the decision taken. Then, the procedure to be followed is the same as laid out above.

1.E. MANUFACTURING LOCATION

This section is a narrative intended to provide all required information in regards to manufacturing interface and controls, carshell final assembly facility and stationing, and material controls that are keyed to a flow chart. This section also addresses CAF's Quality Assurance plan and documentation resources. Throughout this section, the numbers in parenthesis refer to the Manufacturing Flowchart (see Figure 8).

1.E.1. LOCATION

CAF will utilize Zaragoza for carshell manufacturing, Beasain for truck frames manufacturing and Elmira (NY) for final assembly of all vehicles and trucks.

1.E.2. TEAM

The Manufacturing Department will carry out the manufacturing phase of this project. CAF will propose a fully experienced and multidisciplinary Manufacturing Team in order to fulfill with SDOT's required technical specifications. All the proposed key personnel have worked in similar projects before (see Résumés in Sub-Part C Section C) and have extensive experience.

For each project, the Production Director appoints a Manufacturing Manager, Carshell Manufacturing Manager, a Trucks Manufacturing Manager and a Final Assembly Manager.

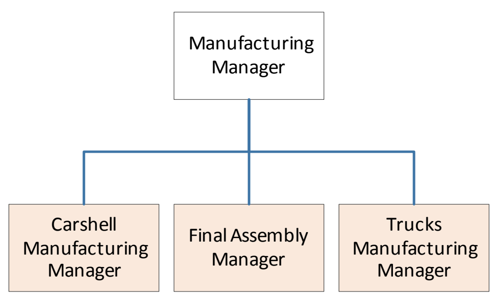


Figure 6. Manufacturing organizational chart for the project

The next bullets show the main responsibility for the managers of the manufacturing stage:

- Manage and oversee the daily manufacturing operations.
- Oversee and monitor the progress of the Production Plan, reporting any change to Schedule Manager and Project Manager.
- Make optimum use of the available resources in the factory in terms of equipment and machinery for the production unit.
- In case of issues in the production stage, report to Project Manager and Project Lead Engineer.
- Once a solution has been agreed to, coordinate the implementation of changes in the production area.

- Oversee the repair and maintenance of all the production equipment.
- Manage the training plan of the production team members.

1.F. INTERFACE AND CONTROLS

1.F.1. PROJECT KICK-OFF PHASE

CAF's previous experience has shown the vital importance of fast project mobilization, between NTP and the start of basic engineering.

The confirmation and appointment of the Project Team (1) is CAF's first task subsequent to contract award. Each Department Head confirms the Project Team Members identified during the proposal phase. The Project Team includes the Project Manager and staff, and representatives from all Departments and Manufacturing Divisions, ensuring efficient communication and coordination between the Project Team and the functional organization of the factories.

The first task of the Project Team is to produce the Project Management Plan (2). This document will be submitted to SDOT for approval and defines:

- Project organization and responsibilities
- Project schedule
- Design management
- Documentation and data control
- Program changes.
- Quality management

Subsequently, the Project Manager convenes an internal kick-off meeting to ensure an efficient and rapid project mobilization. The Factory Director, the heads of all CAF departments and the complete Project Team attend this meeting lead by the Project Manager. The agenda for this meeting typically includes tasks such as introduction of the Project Team, information about the Customer, Contract Review (3) including assignment of responsibilities and specific characteristics of the vehicles.

The final kick-off task of the Project Team is the development of the Mobilization Plan (4). The Mobilization Plan defines actions required to fulfill the first contractual obligations, and assigns responsibilities within each department to expedite performance of the project.

Soon after the development of the Mobilization Plan, CAF will organize a joint kick-off meeting with SDOT following a philosophy similar to that of the internal kick-off meeting. The main purpose of this meeting will be to present the Project Management Plan, the Contract Review details and the Mobilization Plan to SDOT.

1.F.2. PROJECT MOBILIZATION–INTERFACE BETWEEN DESIGN AND MANUFACTURING

The Planning Department, based on the SDOT's required Contract delivery schedule, identifies the main activities and milestones (5), and establishes the critical path for the project, which is included in the Preliminary Project Schedule.

All departments will study the Preliminary Project Schedule and will submit their inputs to the Planning Department. The Scheduling Engineer, based on the comments received from the various departments, will develop the Master Program Schedule (6) that will include all activities from the onset of the project through the delivery, testing and commissioning of the vehicles.

Simultaneous to the creation of the Master Program Schedule, the Scheduling Engineer will draw up the Manufacturing Program (7), which contains the planning for the various production positions, forwarding to tests, and factory dispatching for each streetcar in the contract. The Scheduling Engineer will periodically update the production plan according to actual project progress. The production plan can only be modified following an agreement with the industrial operations management.

In parallel with the scheduling tasks, the Engineering Department starts with the preliminary review and analysis of the contractual requirements. A specifically assigned Design Team will plan, manage and develop the design process (8).

The Engineering Department in close co-operation with the manufacturing divisions, Quality Assurance Department, and After Sales Department develops the Concurrent Engineering Plan (9). The purpose of the concurrent engineering plan is to analyze the feasibility of the design and ensure the incorporation of quality assurance, manufacturing engineering, maintainability, testing, and other project requirements in the design. CAF forms multi-discipline teams responsible for implementing the Concurrent Engineering Plan through all design phases.

The Quality Assurance Department develops the project-specific Quality Assurance Program Plan. Quality Assurance works with the Engineering Department to develop the Test Plan.

1.G. INTERFACE AND CONTROLS BETWEEN CAF AND SUBCONTRACTORS

The Planning Department generates Procurement Orders based on documents provided by the Engineering Department, including the List of MSIs (Major Subcontracted Items), Approved Drawings, and Material Specifications. The Procurement Orders include milestone dates, manufacturing sequence, batches, material destinations, and other relevant information.

Using this information as well as technical and commercial bids, the Procurement Department together with Systems Engineering selects (11) the equipment subcontractors and finalizes the Supply Contracts (12). The Supply Contracts identify all technical, commercial, quality, systems assurance, engineering interfaces, documentation, training, and other necessary requirements for project development.

Once the sub-contracts have been executed, the Project Procurement Manager is responsible for management and control (13) of the equipment subcontractor activities. The Procurement Manager coordinates design and manufacturing tasks between subcontractors and CAF.

Coordinated by the Purchasing Department, CAF system engineers supported by the Quality Assurance Department will make site visits to the subcontractor facilities to verify whether the manufacturing process is proceeding according to plan. A Systems Engineer will monitor compliance with specifications and schedule. CAF inspectors will monitor on a regular basis, the assembly processes and the subcontractor's factory testing. The Quality Assurance Department will carry out the First Article Inspections and Tests (14) according to pre-established procedures. The coordination function of the Procurement Department concludes with the FAI, production tests, and delivery of the equipment.

The Procurement Department is also responsible for the purchase (15) of other components and materials (wiring, linings, windows, etc.) based on CAF's drawings and specifications. The Procurement Department controls (16) this task with the Planning Department, Quality Assurance Department, and Manufacturing Departments. This function concludes with material being delivered to the factory and its inspection (17) by Quality Assurance.

1.H. MANUFACTURING WORK FLOW AND STATIONING

The Manufacturing Divisions receive the Manufacturing Orders (18) from the Planning Department together with inputs from the Engineering Department and initiate the manufacturing processes following the Work Route required by the Planning Department. The Work Route is a document generated by the Planning Department, utilizing software tools, that specifies all operations that have to be accomplished for the manufacture of every component or subassembly.

1.H.1. CARSHELL MANUFACTURING (19)

The Carshell Assembly Division will receive the assembly orders and work procedures from the Planning Department, together with the technical drawings and other documentation from the Engineering Department and the Manufacturing Dossier from the corresponding Production Engineering Department. The carshell assembly will start with the manufacturing of subassemblies (1 - Sides, 2 - Headwalls 3 - Underframes and 4 – Roofs, as shown below)

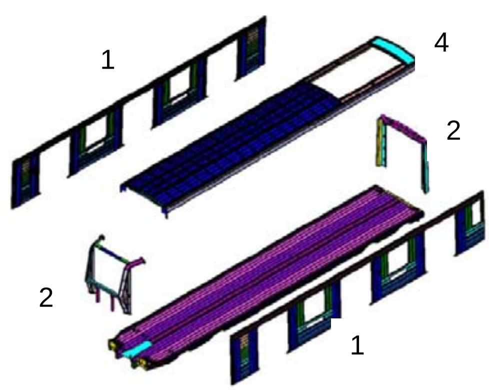


Figure 7. Carshell assembly

The first assembled carshell will be subjected to the FAI. All subsequent finished carshells will undergo series testing before going to the painting process.

1.H.2. TRUCK ASSEMBLY (20)

Truck assembly will consist of two production lines, which will be independent of the carshell assembly line. The Truck Assembly Division will receive the assembly orders (21) and work procedures from the Planning Department together with the technical drawings and other documentation from the Engineering Department.

The first assembled trucks will be subjected to the FAI. All subsequent finished trucks will undergo series testing before being assembled to the carshells. The final assembly of the trucks in Elmira includes mounting of the wheel sets, bolster beam, primary and secondary suspensions, traction motors and brake calipers to the truck frame.

1.H.3. OTHER SUBASSEMBLIES (22) AND FINAL ASSEMBLY (23)

Other subassemblies will consist of cabinets and operator's desk assemblies. The assembly divisions will receive the assembly orders defined by Engineering Department and Planning Departments. The first assembled cabinet and desk will be subject to the FAI.

Once assembled, the subassemblies will be introduced in the final assembly line, as indicated in the flowchart.

CAF will organize final assembly process based assembly optimization studies. Generally, the final assembly process is divided in 5 steps, as shown in Figure 9.

1.H.4. FACTORY TESTING

The first carshell will be subjected to compression testing in Spain. Finished series cars will be moved to the test area for factory testing. The Elmira facility has a fully equipped test track for dynamic test as well as a static test area (24).

1.H.5. MANUFACTURING AND PLANNING FLOW CHART

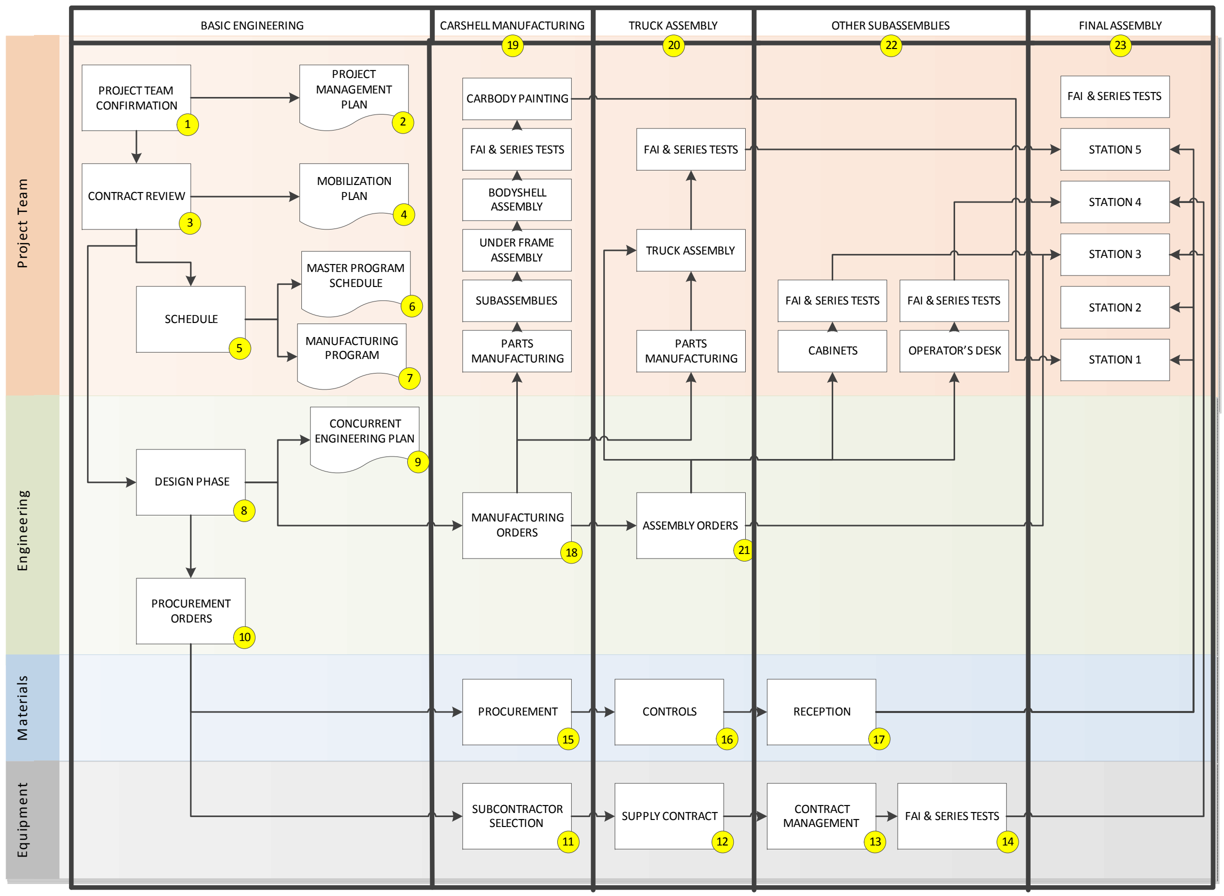


Figure 8. Manufacturing Flowchart

1.H.6. FINAL ASSEMBLY STATIONS

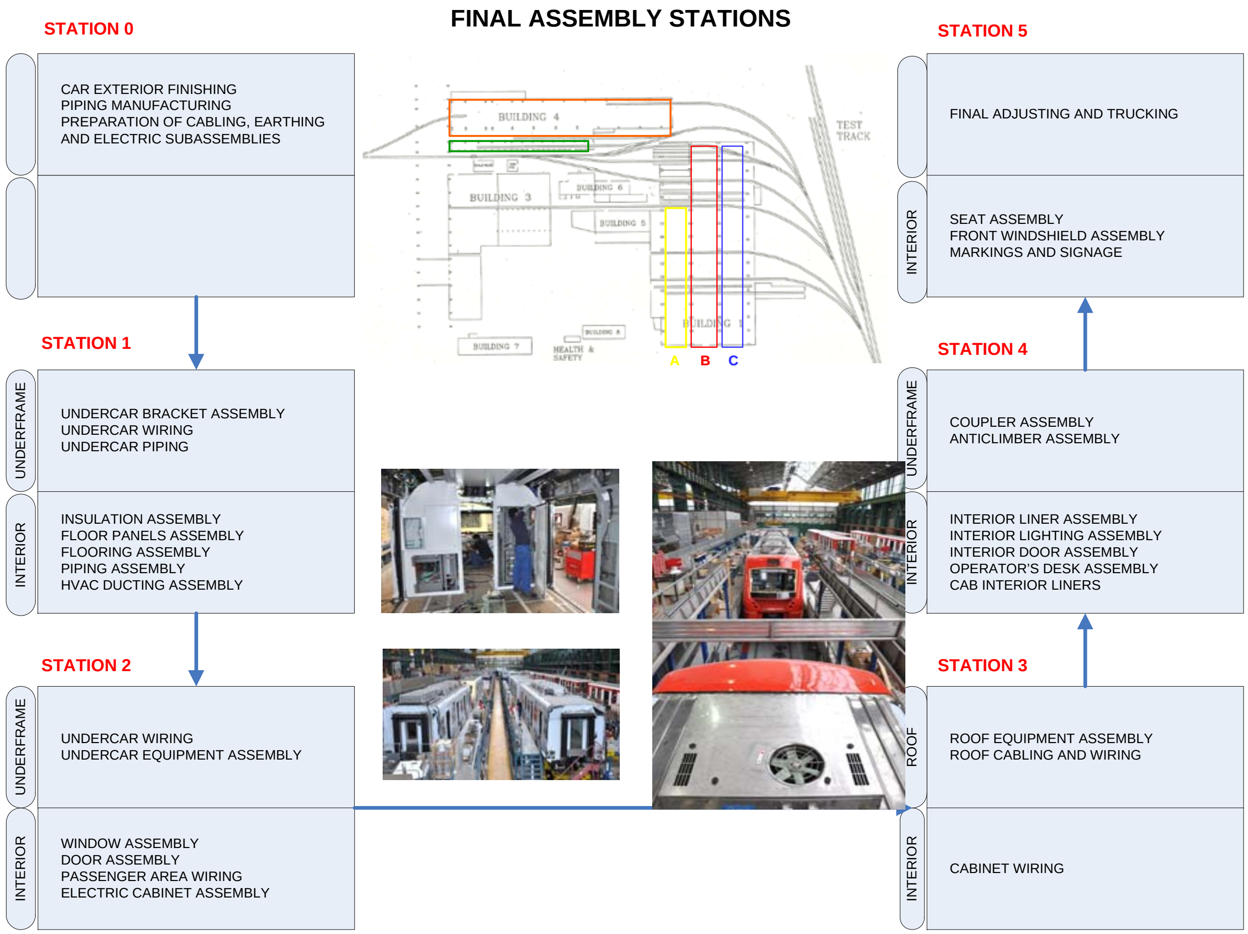


Figure 9. Final Assembly Flowchart

1.I. MATERIAL CONTROL

Materials for SDOT vehicles will be in accordance with the specification or cited standard. If CAF proposes an alternate standard, it will be submitted in English, with a narrative comparing both standards, and citing justification as to why the substitution is equivalent, and will seek SDOT's approval.

CAF will identify all material by its commercial trademark, name, and address of the supplier. CAF will submit a description, and the technical data specifications, of the material composition for approval; CAF will supply SDOT with the vendor who supplied the part and vendor's part number. CAF will maintain records that trace all materials to their manufacturers, and shall verify compliance with quality standards specified or cited in the Technical Provisions of the RFP. Single-source materials will not be supplied unless approved by SDOT.

During the design process CAF will submit all materials utilized in the vehicle to SDOT for approval. CAF will keep a running list of all materials used in the vehicle in matrix format (the matrix shall contain; material name, specification or material ID number, application, approval status, correspondence number, etc.). CAF will submit this matrix along with material certifications and material property test reports to SDOT for review. All joining and fastening data, specifications, and standards for all types and methods of fastening and joining used will be submitted for SDOT's approval.

The material control program is implemented by participants from different departments;

Work flow plans are prepared by Manufacturing Engineering to optimize material flow, reduce handling and ensure quality. The necessary materials, tools and special equipment are staged at each station.

Production Management prepares the schedule for manufacturing to comply with the project schedule which is prepared by the Planning Department. The schedule is typically prepared per car, by station.

Manufacturing Engineering prepares procedures used for assembly. Depending on the complexity of the operation these can take various forms, from drawings and checklists to detailed work instructions.

The Quality Manager reviews the contract specifications and produces plans and procedures to fulfill the requirements. The Quality Team, through planned inspections and audits, will ensure an acceptable level of quality throughout the program. The audits performed by the Quality Team are internal and external, and include supplier facilities.

The Warehouse Manager and team control material from receiving to delivery to the production line. After release from Receiving Inspection all materials are documented, tagged and stored in dedicated indoor locations protected from exposure to the elements. Materials are then delivered to manufacturing as necessary to support the production schedule. Strict policies and controls are in place regarding access by personnel to all warehouse storage areas, assuring a secure environment.

1.J. QUALITY ASSURANCE PLAN

Since 1990, CAF has been working on a Quality Management system aligned with ISO 9001. The first certification was achieved in 1994, according to ISO 9001:1994 standard. The scope of the certificate is: "Design, manufacturing, servicing, repairing/transforming and maintenance of railway vehicles and bogies". In 2003, the CAF Quality Management system was adapted to the standard EN-ISO 9001:2000, and currently is ISO 9001:2008 and IRIS rev.02 certified.

CAF is also ISO 14001 and BS OSHAS 18001 certified. Additionally, CAF's wheels and axles Business Unit (CAF Miira) is AAR M-1003 and IRIS certified as well.

1.J.1. QUALITY ASSURANCE MANUAL

CAF's Quality Assurance Manual (known as "Quality Manual" within CAF) is ISO 9001:2008 and IRIS Rev.02 certified. The Quality Manual lists CAF's procedures (see list in Figure 15) that describe the methods for planning, implementing, and maintaining quality assurance.

The Quality Manual contains all elements to comply with ISO 9001:2008 and IRIS Rev.02 standards requirements. Therefore, the procedures and statements included in the Quality Manual are mandatory for all CAF projects and activities.

After NTP, CAF will submit the latest edition of the Quality Manual (mandatory). The following figure shows the structure of the Quality Manual.

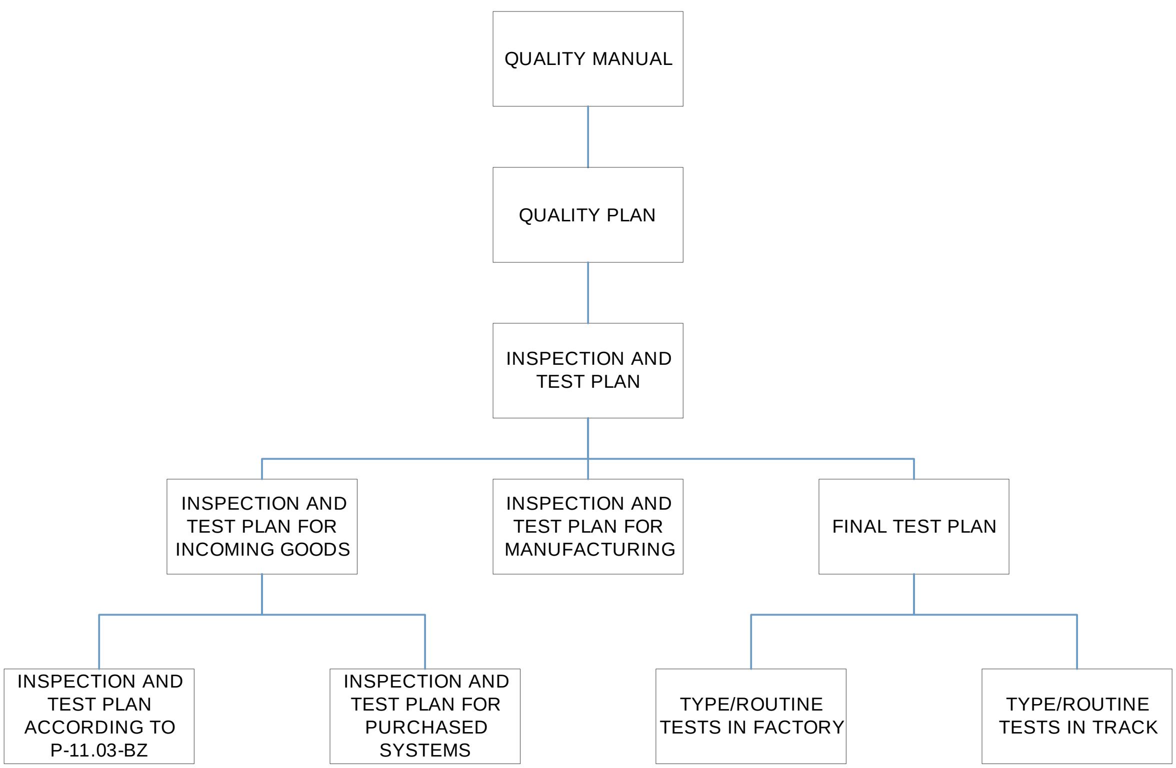


Figure 10. Quality Manual structure

1.J.2. QUALITY PLAN

After NTP, CAF will submit a project-specific Quality Assurance Program Plan (QAPP), known as "Quality Plan" within CAF, for approval. The QAPP will provide objective technical evidence of the adequacy of the Contractor's Quality Assurance Program to assure product compliance.

Engineering, procurement, manufacturing, inspection and test procedures and plans applicable to the project and required to ensure compliance with all contract requirements, will be developed using the methods and procedures established in CAF's Quality Manual and listed in the QAPP.

The QAPP will include a company policy statement that clearly defines its objectives and commitment to quality.

The QAPP will be developed following the ISO 10005 standard (guidelines for quality plans), that gathers all requirements of ISO 9001.

This Plan includes all items from CAF's Quality System such as: project description, Quality system, Management responsibilities, Contract Review, Design Control, Document and data Control, Purchasing, Control of Customer Supplied Products, Product Identification and Traceability, Process Control, Inspection and Testing and Test Status, Inspection Measuring and Test Equipment, Nonconforming Products and Corrective Actions, Handling Storage Packaging and Delivery, Quality Records, Quality Audits, Training, and After-sales Service. All of these activities are shown in the attached Quality Assurance Flow Chart (see Figure 16).

1.J.3. INSPECTION AND TEST PLAN

After NTP, CAF will submit the Inspection and Test Plan (ITP) for approval. According to the QAPP, an Inspection and Test Plan will be defined to identify the controls to be applied during all stages of the project. This Inspection and Test Plan will include:

- Inspection and Test Plan for Incoming Goods.
- Inspection and Test Plan for Manufacturing.
- Final Tests Plan (including factory and in-track testing).

The ITP will include a list of all major components and subassemblies proposed to receive a First Article Inspection, and will identify the "witness" and "hold" points, as well as the quality records to be delivered to SDOT.

1.J.4. CONFIGURATION MANAGEMENT

A specific configuration management plan is developed in each project, in order to know the configuration status of the vehicles at any given moment, and to define how to propose, approve, implement and track any change to the configuration.

A configuration tree is defined, including all relevant hardware and software elements of the vehicle (for both CAF and subcontractors and suppliers), as follows:

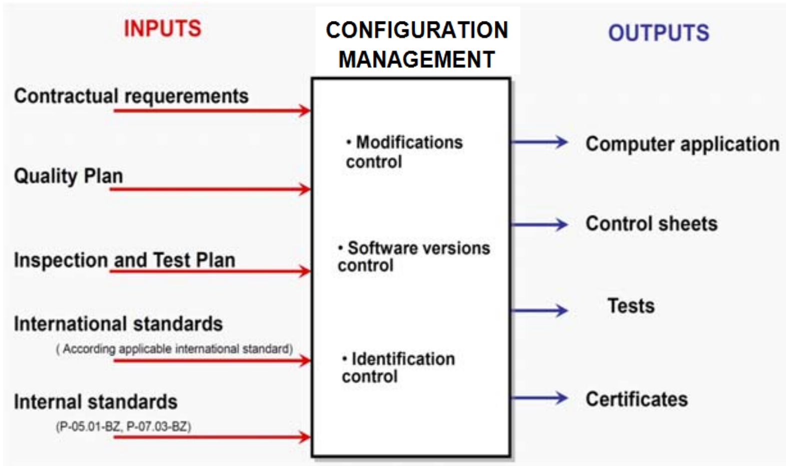


Figure 11. Configuration Management

1.J.5. DESIGN VERIFICATION PLAN

A Project Design Verification Plan based on DOORS© (Dynamic Object Oriented Requirements System) software is defined in order to specify the methods used by CAF to verify each Design Package, and ensure that it has been designed in accordance with the requirements of the project agreement.

The steps followed in the design verification plan are:

- Design review (Concept design, Preliminary design, Final design)
- Monitoring of design verifications
- Validation of design by testing

For each project, a senior engineer from the Engineering Department is appointed as Lead Engineer and Design Authority, leading the Project Design Team made up of qualified individuals (one expert of each area of the Engineering Department).

1.J.6. PURCHASING

The suppliers of the products or services and the subcontractors are evaluated and selected according to their ability to satisfy the specified requirements and to effect a high-quality final product. The evaluation system consists of Initial Approval, Periodical Evaluation and Updating of the List of Approved Subcontractors and Suppliers.

The operating method, the resulting responsibilities and the criteria followed for the approval of suppliers are described in procedure P-07.01-BZ “Approval of Suppliers”, available upon request.

Purchase specifications will require that all purchased materials, equipment, and services comply with the Contract specification requirements and with CAF material, quality, workmanship, and performance criteria.

An evaluation of the supplier deliveries will be carried out based on the degree of compliance of the specified requirements according to the procedure P-07.07-BZ “Continuous Evaluation of Suppliers”, (available upon request).

Suppliers and subcontractors are not allowed to carry out design modifications without previous approval, and a corresponding certificate of compliance will be required (if applicable).

In addition, CAF and/or SDOT will be allowed to conduct inspections at the supplier’s facilities, as stated in the General Purchase Conditions included in the purchase order.

1.J.7. DEVIATION MANAGEMENT

CAF has defined a system to ensure that products not conforming to the established requirements are identified, controlled and segregated from the production flow.

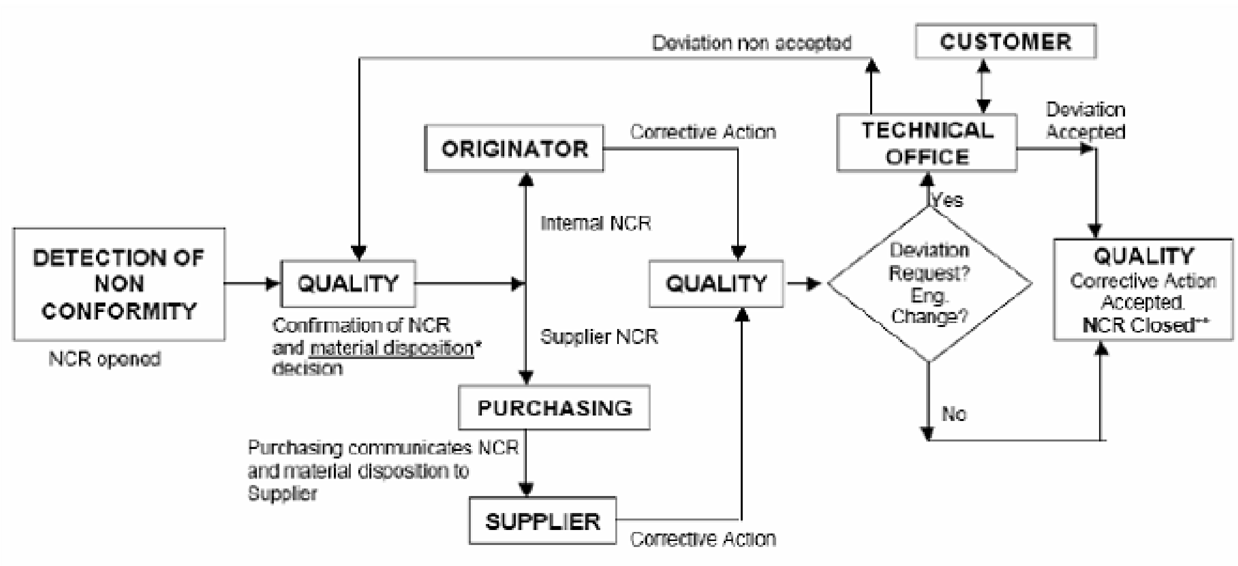
The system applies to all areas and processes within CAF, from design to vehicle commissioning.

Any non-conforming material detected will be clearly identified and segregated to avoid its use and a Non-Conformance Report (NCR) document will be created. Non-compliant or defective materials will be kept in the “NCR Area” until final disposition: scrap, return to supplier, repair or use “as is”. For rework or use “as is” dispositions, written authorization will be required from SDOT.

CAF has defined a Material Review Board procedure in order to manage the non-conforming materials, and will maintain record of all materials entered into the “NCR Area”, with the description of deficiencies and final dispositions.

The NCR Management flowchart is shown in Figure 12.

NCR MANAGEMENT



Non conformity can be detected in:
Incoming Inspection
- **Manufacturing**
- **Testing**
- **Customer claim …**

NCR Originator can be:
- **Manufacturing**
- **Logistics**
- **Supplier …**

Material Disposition can be:
- **Scrap**
- **Return to Supplier**
- **Rework**
- **Deviation Request…**

All deviations, eng. Changes… need to be addresses by technical office (Design).

Figure 12. NCR Management Flowchart

1.J.8. TESTING AND COMMISSIONING

Testing is carried out in accordance with the Final Tests Plan included in the Inspection and Test Plan, in order to ensure that the train has the desired functionality before takeover. The Final Tests Plan includes:

- Bogie Final Tests (electric resistance verification, electric isolation verification, pneumatic equipment verification, etc.)
- Vehicle Final Tests (factory type tests, type tests on track, factory routine tests, routine tests on track)
- Commissioning: Any additional activities required for commissioning purposes.
- Reception/Approval: Any additional test required for reception/approval of the vehicle on SDOT's facilities.

The testing processes are stated in the procedure P-11.02-BZ "Final tests and trials", available upon request.

The list of tests will be agreed with SDOT and included in the Inspection and Test Plan once the basic engineering is completed. The content of the Test Protocols is submitted by the Engineering department to SDOT for review and approval.

1.J.9. CAF'S QUALITY ASSURANCE STRUCTURE

The structure of CAF's Quality Department is shown in the organization chart below. Manufacturing Department and Quality Department are completely separated; the only hierarchical relationship is that both departments are under command of the Chief Executive Officer. Because of this, manufacturing leaders have no influence regarding the Quality Department inspectors and staff.

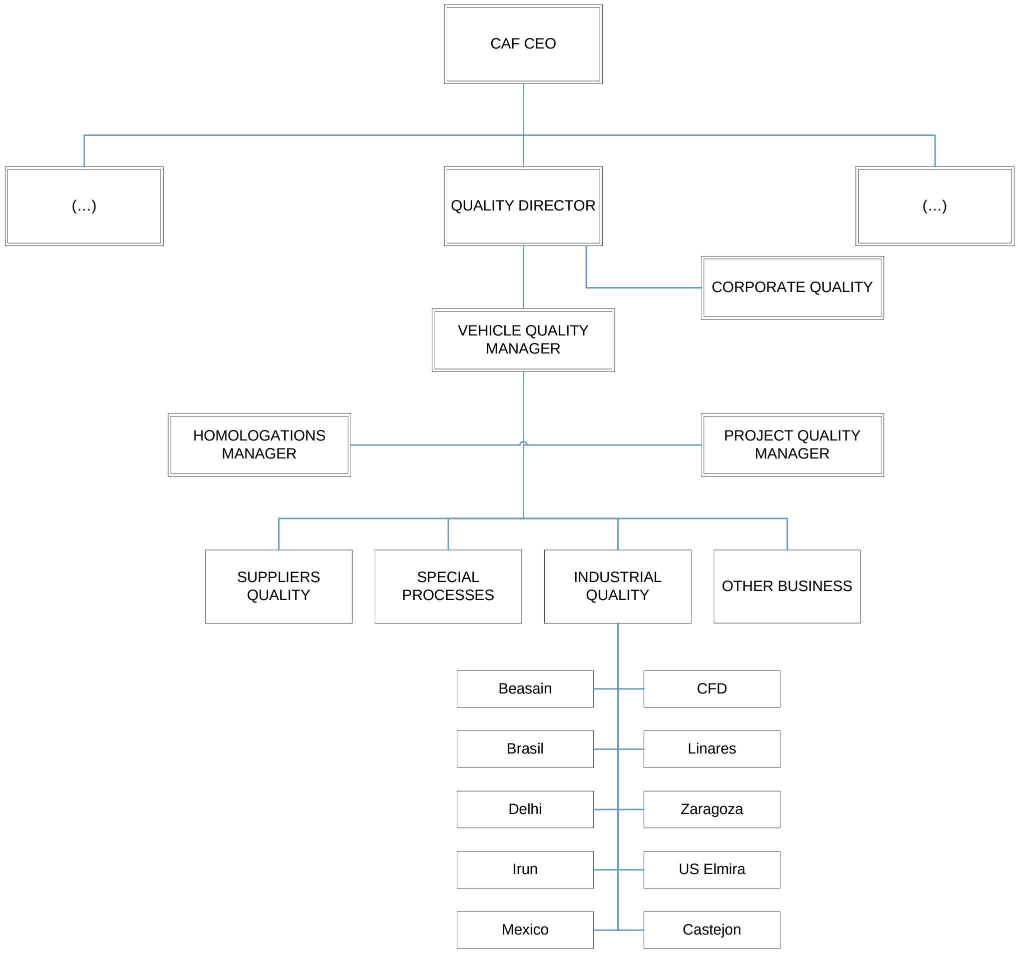


Figure 13. CAF Quality Organization Chart

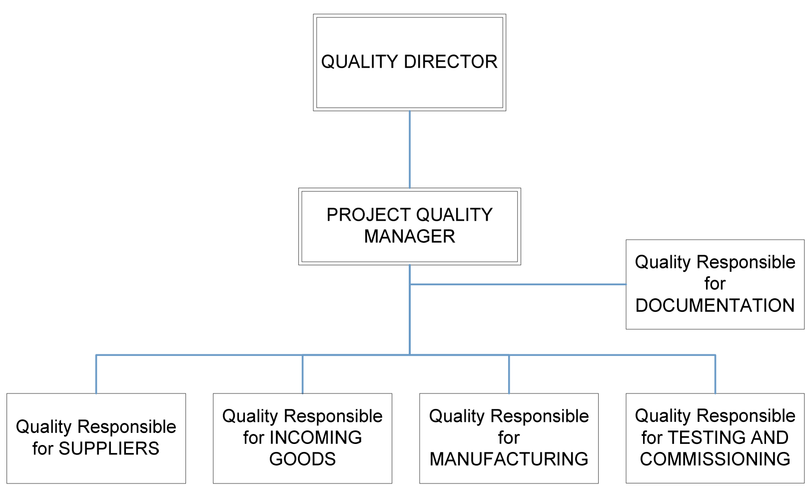


Figure 14. Elmira Quality Organization Chart

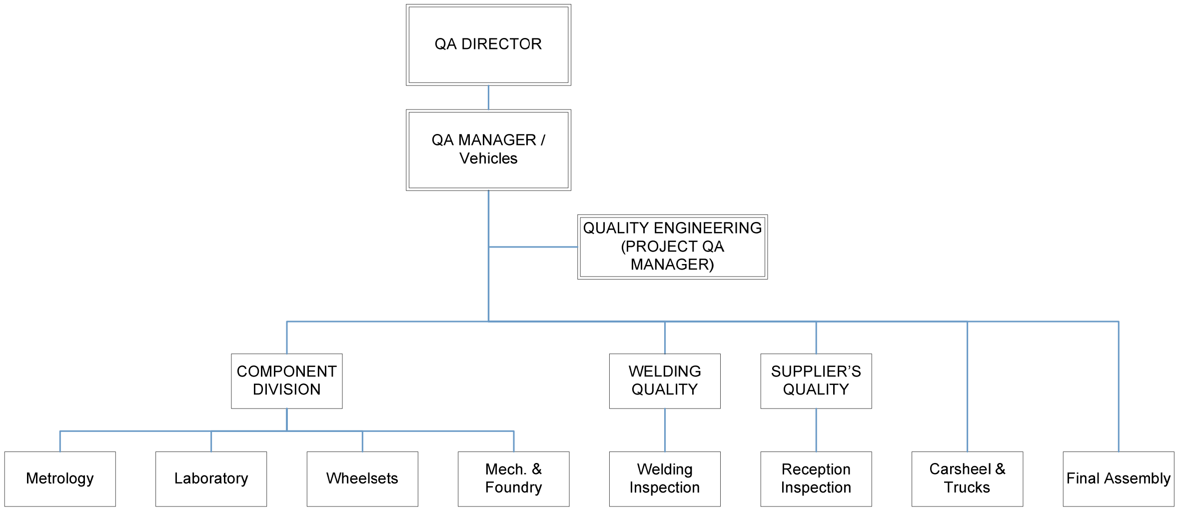


Figure 15. Beasain Quality Organization Chart

The proposed Project Quality Manager will depend functionally and hierarchically on the Quality Director. The Project Quality Manager will report to the Quality Director and will be independent with respect to other departments involved in the project.

1.K. DOCUMENTATION RESOURCES

CAF has a dedicated staff whose responsibility is to maintain and update the documentation databases with several kinds of documentation generated during the project (specifications, blueprints, applicable standards, meeting reports, etc.)

The documents generated for the project are available as electronic files using our documentation management software, and are available through any personal computer once a correct ID and password is provided.

CODE	DESCRIPTION
P-02.01-BZ	STRUCTURE AND ORGANIZATION
P-03.01-BZ	QUALITY PLANNING
P-04.01-BZ	CONTRACT REVIEW
P-04.02-BZ	OFFERS
P-04.03-BZ	REVIEW OF OFFERS AND REQUESTS FOR THE T.M.G. SHOP
P-05.01-BZ	DESIGN CHANGES
P-05.02-BZ	DEVELOPMENT OF DESIGN
P-05.03-BZ	DESIGN VERIFICATION AND VALIDATION
P-05.04-BZ	DESIGN REVIEW
P-05.05-BZ	PROJECT PLANNING AND DEVELOPMENT
P-05.06-BZ	MANAGEMENT OF THE SUBCONTRACTED DESIGN
P-06.01-BZ	PROCEDURE CREATION AND CONTROL

P-06.02-BZ	CONTROL OF DOCUMENTATION
P-07.01-BZ	APPROVAL OF SUPPLIERS
P-07.02-BZ	AUDITING SUPPLIERS QUALITY MANAGEMENT SYSTEM
P-07.03-BZ	MANAGEMENT OF PURCHASED MAIN ELEMENTS/SYSTEMS
P-07.04-BZ	PURCHASE DOCUMENTATION
P-07.07-BZ	CONTINUOUS EVALUATION OF SUPPLIERS
P-08.01-BZ	PRODUCTS SUPPLIED BY CUSTOMERS OR PARTNERS
P-08.02-BZ	MEASUREMENT OF CUSTOMER SATISFACTION
P-09.01-BZ	IDENTIFICATION AND TRACEABILITY
P-10.01-BZ	NOMENCLATURE PREPARATION AND PUBLICATION
P-10.02-BZ	PRE-ASSEMBLY AND ASSEMBLY PROCESS CONTROL
P-10.03-BZ	PAINTING PROCESS CONTROL
P-10.04-BZ	WELDING PROCESS CONTROL
P-10.05-BZ	CARBODY AND BOGIE FRAME MANUFACTURING PROCESS CONTROL
P-10.06-Z	DOORS MANUFACTURING PROCESS CONTROL
P-10.07-BZ	SHEETMETAL WORK PROCESS CONTROL
P-10.08-BZ	SURFACE TREATMENT OF SIDERURGICAL MATERIALS
P-10.09-B	FINAL BOGIE ASSEMBLY PROCESS CONTROL
P-10.11-BZ	WIRING PREPARATION PROCESS CONTROL
P-10.12-B	PIPING MANUFACTURING PROCESS CONTROL
P-10.13-BZ	PRODUCTION INFRASTRUCTURE MAINTENANCE
P-10.14-B	MACHINING PROCESS CONTROL
P-10.15-B	ASSEMBLY PROCESS CONTROL
P-10.16-BZ	BONDING AND SEALING PROCESS CONTROL
P-11.01-BZ	QUALITY PLANNING IN MANUFACTURING
P-11.02-BZ	FINAL TESTS AND TRIALS
P-11.03-BZ	INCOME INSPECTION AND TESTING OF MATERIALS
P-12.01-BZ	INSPECTION, MEASURING AND TESTING EQUIPMENT
P-13.01-BZ	INSPECTION AND TESTING STATUS
P-14.01-BZ	IN-MANUFACTURING NON-CONFORMANCE MANAGEMENT
P-14.02-BZ	INCOME NON-CONFORMANCE MANAGEMENT
P-15.01-BZ	CORRECTIVE AND PREVENTIVE ACTIONS
P-16.01-BZ	HANDLING, STORING, PACKAGING, PRESERVATION AND DELIVERY
P-17.01-BZ	CONTROL OF QUALITY RECORDS
GeSgCa	QUALITY MANAGEMENT SYSTEM, INTERNAL AUDITS
P-19.01-BZ	TRAINING
P-20.01-BZ	TREATMENT, ANALYSIS AND USAGE OF INFORMATION FROM T.S.S.
P-20.02-BZ	TRAINING OF T.S.S. (TECHNICAL SUPPORT SERVICES) PERSONNEL
P-20.03-BZ	MANAGEMENT OF SPARE PARTS
P-20.04-BZ	PROVISION OF TECHNICAL SUPPORT SERVICES
P-20.05-BZ	ORGANIZATION OF AFTER-SALES TECHNICAL ASSISTANCE

Figure 16. QA Procedures available upon request

1.L. QUALITY ASSURANCE FLOW CHART

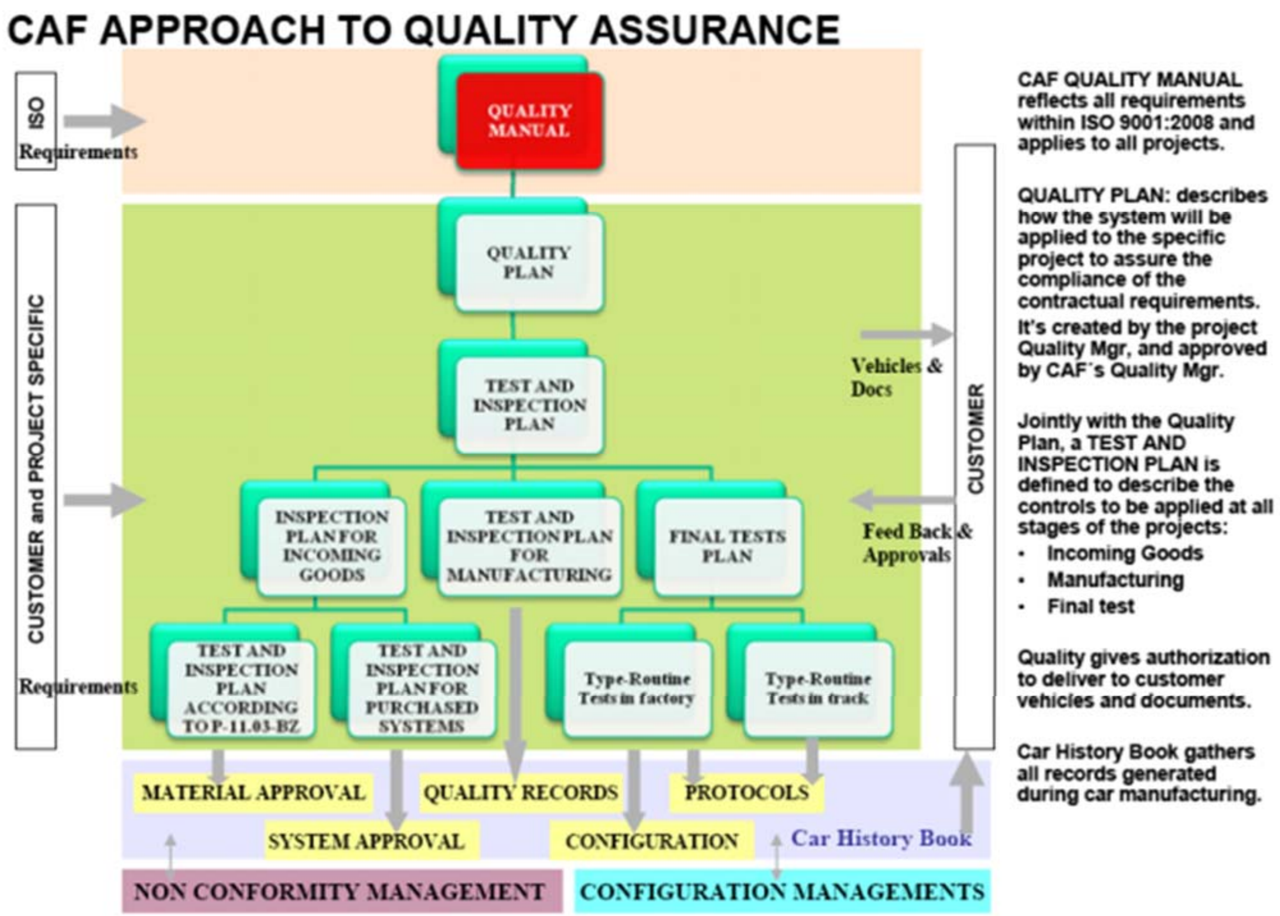


Figure 17. Quality Assurance Flowchart

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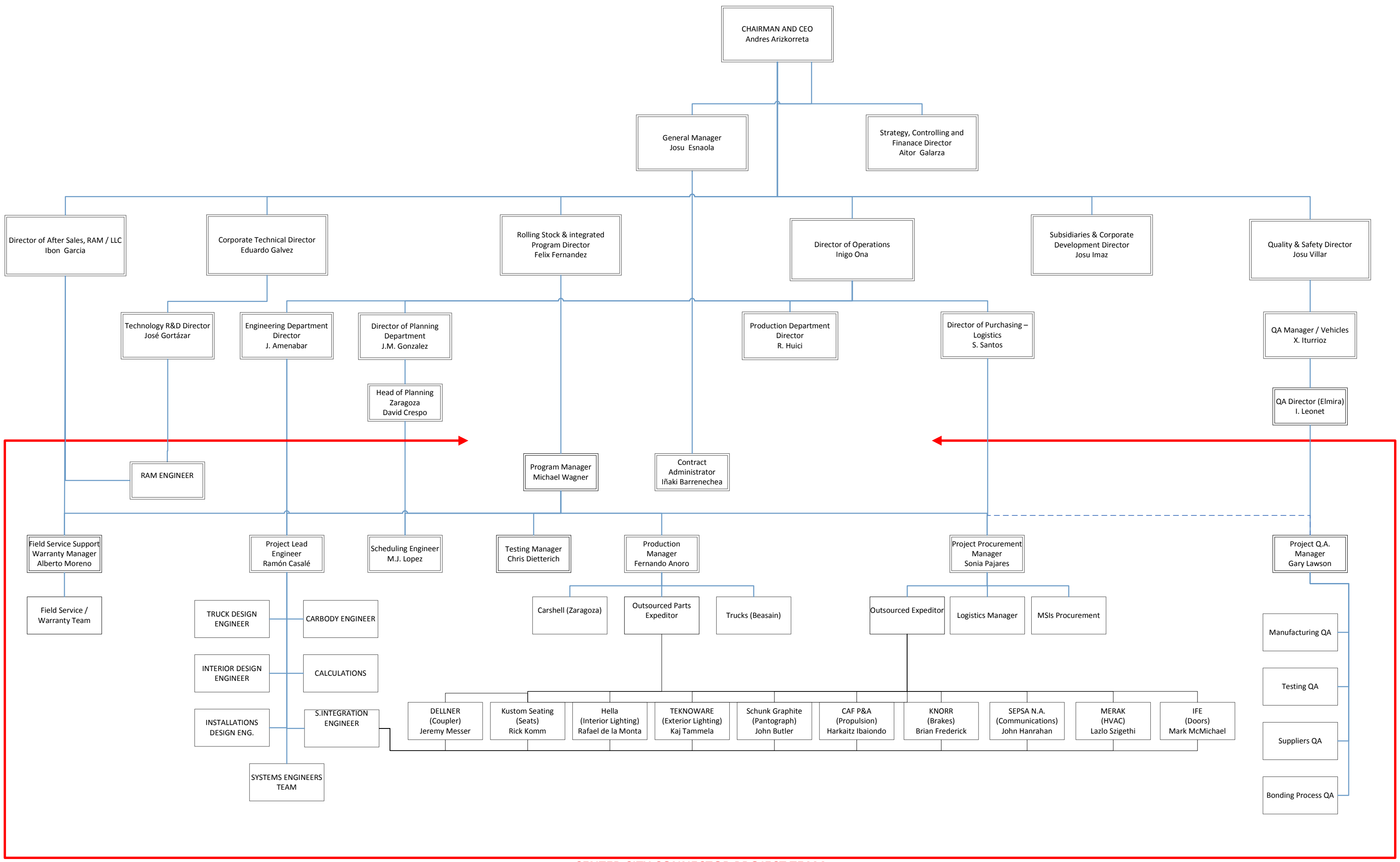
SECTION B ORGANIZATION CHART

A. ORGANIZATIONAL CHART



CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

city of CINCINNATI
OFFICE OF THE CITY MANAGER

INSPECTION AND TESTING PLAN

CINCINNATI STREETCAR
Contract nr. 25X7331

Code:	**Q.41.96.902**		
Issue:	**F**		
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	23/10/14	B	Update according customer comments CINCAF529 and General Review, acc.Q.41.92.100;.200&.300.
	08/04/15	C	Update according customer comments (CINCAF-0756) and General Review, acc.Q.41.92.100Ed.B;.200Ed.B&.300Ed.A
	17/07/15	D	Update acc. customer comments CINCAF-1023; Q.41.92.100Ed.C.
	22/09/15	E	Update acc. customer comments CINCAF-1149; Q.41.92.300Ed.B.
	06/11/15	F	Update acc. customer comments CINCAF-1235; Q.41.92.100Ed.D.

Edited by	David Paricio	Project Quality Manager	
Approved by	Ramón Ichaso	Quality manager - CAF Zaragoza	

1.- Purpose

This Inspection and Testing Plan (Q.41.96.902) is prepared in accordance with the requirements in the CINCINNATI STREETCAR CONTRACT nr. 25X7331 and responds to "Quality Control and Inspection Plan" Chapter 18.9.2 of Cincinnati Streetcar Technical Specifications**.**
The purpose of this Control Plan is to integrate in a single document all operations of inspections, controls and tests to be performed during the processes related to the production of the Units in this project, as well as all the documentation associated with these controls.

2.- Scope

This Inspection and Testing Plan is applicable to the supply of 5 streetcars of three (3) cars each (and, in case any, additional Streetcar to be supplied pursuant to any options exercised by the Purchaser): Cincinnati Streetcar Contract nr. 25X7331 for the City of Cincinnati.

3.- Applicable documentation

The Inspection and Testing Plan preparation is subject to the following:

- **Delivery Agreement** Cincinnati Streetcar Contract nr. 25X7331 for the City of Cincinnati.
- UNE-EN-ISO-9001 – Quality Management Systems. Requirements.
- CAF Rail Vehicle Quality Manual.
- Q.41.92.100 (Test List at supplier facilities); Q.41.92.200 (Test List in CAF Factory facilities) and Q.41.92.300 (Test List on Track): Documents developed by CAF Engineering which contains the list of tests to be carried out in Cincinnati Project in terms of Component Qualification/Acceptance Tests, Factory Qualification/Acceptance Tests, On-Track Qualification/Acceptance Tests.
- CAF is aware of (CINCAF-756&1023) and will comply with TS, routine factory testing will be part of the FAI process (FAI's performed internally and also at supplier facilities).

4.- Responsibilities

- Project Quality Manager: Responsible of Definition the Inspection and Testing Plan, as well as maintain it.

- Department Quality manager: Responsible of Approval of the Inspection and Testing Plan.

5.- Definitions / Abbreviations

• **CONTROL PLAN:** Master document that compiles all the controls performed by CAF in the context of a project and the subsequent documentation.

• **CONTROL RECORD:** Record to be signed at least by Production departments and Quality Assurance which justifies the fulfilment of the requirements defined. It is a document usually delivered to the customer.

• **CONTROL SHEET:** Internal Control document of the different manufacturing stages. It is not delivered to the customer

• **WITNESS POINT (W):** Point in the Control Program agreed with the customer to be noticed. There is no need to stop the production activities independently of the customer's assistance.

• **HOLD POINT (H):** Point in the Control Program agreed with the customer to stop the production activities until its customer's witness, unless there is a documented refusal. These points must be noticed in an unmistakable way.

• **O** : Inspection in Origin (out of CAF´s Facilities, for example in CAF´s supplier facilities, Cincinnati Acceptance Site,…)

• **I** : Inspection internal (in CAF Facilities)

• **I/O***: Details of location of the test at the official Project Schedule

• **F** : Manufacturing Department

• **C** : Quality Department

• **T** : Engineering Department

• **S** : Supplier

• **R** : Records review

The lists provided in each Annex are to be considered a summary document that may be adjusted as a result of poor, or exceptional, production and test activity and quality levels.

While the line items in each Annex indicate whether or not there will be an FAI/hold point/ witness point, this list, as presented, is not to be considered final. Final consideration shall be made as a result of inspection findings during the build process.

ANNEX 1 - LIST OF INSPECTION AND TEST FORMS

ANNEX 2 - LIST OF FAIs

ANNEX 3 - LIST OF HOLD/WITNESS POINTS

ANNEX 4 - PRE-SHIPMENT INSPECTION

ANNEX 5 - POST-SHIPMENT INSPECTION

ANNEX 6 - CAF&CUSTOMER FINAL INSPECTION

ANNEX 7 - MATRIX - INSPECTION AND TESTING PLAN

ANNEX 1

LIST OF INSPECTION AND TEST FORMS

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
1.2.1	MAIN EQUIPMENT EQUIPOS PRINCIPALES				
1.2.1.1	PROPULSION SYSTEM SISTEMA DE TRACCIÓN	O -	O -	- O	Q.41.92.101.02 Q.41.92.401.02
1.2.1.2	BRAKE RESISTOR RESISTENCIA DE FRENO	O -	O -	- O	Q.41.92.101.03 Q.41.92.401.03
1.2.1.3	COMBINED TEST ENSAYO COMBINADO	O	-	-	Q.41.92.101.11
1.2.1.4	PANTOGRAPH PANTÓGRAFO	-	-	O	Q.41.92.402.00
1.2.1.5	MASTER CONTROLLER MANIPULADOR DE TRACCIÓN	O -	O -	- O	Q.41.92.105.00 Q.41.92.405.00
1.2.1.6	AUXILIARY POWER SUPPLY/ LOW VOLTAGE POWER SUPPLY/BATTERY CHARGER APS/LVPS/CARGADOR DE BATERÍAS	O -	O -	- O	Q.41.92.121.00 Q.41.92.421.00
1.2.1.7	BATTERY BATERÍA	- -	O -	- O	Q.41.92.422.00
1.2.1.8	BRAKE SYSTEM SISTEMA DE FRENO	O -	O -	- O	Q.41.92.132.00 Q.41.92.132.01 Q.41.92.432.00
1.2.1.9	PASSENGER DOORS PUERTAS DE ACCESO VIAJEROS	O	O	-	Q.41.92.141.00
1.2.1.10	HVAC AIRE ACONDICIONADO	O -	O -	- O	Q.41.92.151.00 Q.41.92.451.00
1.2.1.11	PIS-PAS-PA&CCTV SYSTEM SISTEMA PIS-PAS-PA&CCTV	O -	O -	- O	Q.41.92.161.00 Q.41.92.461.00
1.2.1.12	EVENT RECORDER REGISTRADOR DE EVENTOS	O -	- -	- O	Q.41.92.163.00 Q.41.92.463.00
1.2.1.13	TCMS TCMS	-	-	O	Q.41.92.462.00
1.2.1.14	GANGWAY PASILLO INTERCIRCULACIÓN	O	O	-	Q.41.92.186.00
1.2.1.15	GEARBOX REDUCTORA	O -	O -	- O	M.H1.92.001.00 M.H1.92.002.00
1.2.1.16	LEVELING ACTUATOR ACTUADOR DE NIVELACIÓN	O	I	-	M.H1.92.006.00
1.2.1.17	TRACTION MOTOR MOTOR DE TRACCIÓN	O -	O -	- O	Q.40.92.142.00 Q.41.92.401.01
1.2.1.18	HEATERS CONVECTORES	O -	O -	- O	Q.41.92.151.01 Q.41.92.451.01
1.2.2	OTROS OTHERS				
1.2.2.1	CARBODY STRUCTURAL TEST ENSAYO ESTRUCTURAL DE CAJA	O	-	-	Q.41.92.010.00
1.2.2.2	TRUCK STATIC AND FATIGUE TEST ENSAYO ESTÁTICO Y DE FATIGA DE BOGIE	O	-	-	M.H1.92.010.00
1.2.2.3	FLOOR ASSEMBLY FIRE TEST ENSAYO DE FUEGO MONTAJE SUELO	O	-	-	Q.41.92.101.00
1.2.2.4	ROOF ASSEMBLY FIRE TEST ENSAYO DE FUEGO MONTAJE TECHO	O	-	-	Q.41.92.102.00

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
2.2	**T&I PLAN CARBODYSHELL STRUCTURE MANUFACTURING** *INSPECCION Y ENSAYOS EN FABRICACION DE LA CAJA*				
2.2.1	Cab Underframe Assembly C Cars *Montaje cabecero delantero Coches C*	-	-	I	*Q.41.FC.A025.01*
2.2.2	Welding inspection: Cab headstock C Cars *Inspección soldadura de cabecero delantero Coches C*	-	I	I	*Q.41.90.018*
2.2.3	Dimensional control: Cab headstock C Cars *Inspección dimensional de cabecero delantero coches C*	-	I	I	*Q.41.90.009*
2.2.4	Underframe assembly C/S cars *Bastidor de coches C/S: Montaje*	-	-	I	*Q.41.FC.A025.02* *Q.41.FC.A025.03*
2.2.5	Carshell body Underframe traceability of Casting pieces. *Trazabilidad piezas fundición bastidor de Caja*	-	-	I	*Q.41.90.103*
2.2.6	Dimensional control of Articulation Bolster C/S Cars *Inspección dimensional de Traviesa de Articulación Coches C/S*	-	-	I	*Q.41.90.001/ Q.41.90.002*
2.2.7	Welding control of Articulation Bolster C/S Cars *Inspección soldadura de Traviesa de Articulación Coches C/S*	-	-	I	*Q.41.90.010/ Q.41.90.011*
2.2.8	Welding inspection: Underframe C/S Cars *Inspección de soldaduras de bastidor de caja Coches C/S*	-	I	I	*Q.41.90.012/ Q.41.90.013*
2.2.9	Dimensional control: Underframe C/S Cars *Inspección dimensional de bastidor de caja Coches C/S*	-	I	I	*Q.41.90.003/ Q.41.90.004*
2.2.10	Roof assembly *Montaje de cubierta*	-	-	I	Q.41.FC.A028.02 Q.41.FC.A028.03
2.2.11	Dimensional control: Roof C/S Cars *Inspección dimensional de cubierta Coches C/S*	-	I	I	*Q.41.90.005/ Q.41.90.006*
2.2.12	Welding inspection: Roof C/R/S Cars *Inspección de soldaduras de cubierta Coches C/R/S*	-	I	I	*Q.41.90.014/ Q.41.90.015*
2.2.13	Bodyside assembly *Costado: Montaje*	-	-	I	Q.41.FC.A027.01
2.2.14	Carbody Assembly: *Armado de caja*	-	-	I	Q.41.FC.A030.01
2.2.15	Global control: Carbody - C/S Cars *Control general de caja - Coches C/S*	-	I	I	*Q.41.90.016/ Q.41.90.017*
2.2.16	Dimensional control: Carbody C/S Cars *Inspección dimensional de caja Coches C/S*	-	I	I	*Q.41.90.007/ Q.41.90.008*
2.2.17	Carbody: Control of riveting process *Control proceso remachado en caja.*	-	I	I	*Q.41.90.016/ Q.41.90.017*
2.2.18	Carbody C/S (dimensional): Control in USA *Control Caja (dimensional) C/S en USA*	-	I	I	*Q.41.90.020/ Q.41.90.021*
2.2.19	Carbody Assembly in Elmira: *Armado de caja en Elmira*	-	-	I	Q.41.FC.B027.01
2.3	**BODYSHELL FINISHING. PAINTING PROCESS** *FABRICACION Y ACABADO DE CAJA. PROCESO DE PINTURA.*		I	I	
2.3.1	Carbodyshell painting process control *Control del proceso de pintado de caja*	-	-	I	*Q.41.FC.B058.01 / .02 / .03*
2.3.2	Control of Carbodyshell painted *Control de caja pintada*	-	I	I	*Q.41.90.050*
2.4	**BODYSHELL FINISHING AND ASSEMBLY** *FABRICACION Y ACABADO DE CAJA*		I	I	
2.4.2	**Car finishing. Stage P1** *Montajes de acabado. Posición P1*			I	
2.4.2.3	Connections checking Electrical workshop *Control de conexionados Taller eléctrico*	-	-	I	Q.41.FC.B077.10 / 11 / 12
2.4.2.4	Electrical conduits preassembly *Premontaje conductos eléctricos*	-	-	I	Q.41.FI.B084.01
2.4.2.5	Control mounted subassemblies in electrical workshop (equiped driver desk + cabin cabinets + department panels + battery box) *Control de subconjuntos montados en Taller eléctrico (pupitres equipados + armarios de cabina + paneles departamento + cofre de batería)*	-	-	I	F 14-02-EL-01

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
2.4.3	**Car finishing. Stage P3** *Montajes de acabado. Posición P3*			I	
2.4.3.2	Internal roof assemblies stage 1 *Montajes en interior cubierta fase 1*	-	-	I	Q.41.FC.B048.01 Q.41.FI.B048.01
2.4.3.3	Connections checking *Control de conexionados*	-	-	I	Q.41.FC.B077.00 / 01 / 02
2.4.3.4	External roof assemblies stage 1 *Montajes en exterior cubierta fase 1*	-	-	I	Q.41.FC.B073.01
2.4.3.5	Roof internal wiring inspection *Inspección cableado interior en cubierta*	-	-	I	F 14-02-EL-01
2.4.3.6	Internal roof assemblies stage 2 *Montajes en interior cubierta fase 2*	-	-	I	Q.41.FC.B048.02 Q.41.FI.B048.02
2.4.3.7	Electrical conduits preassembly *Premontaje conductos eléctricos*	-	-	I	Q.41.FI.B084.01
2.4.3.8	Roof inspection prior to assembly *Inspección cubierta previa a su montaje*	-	-	I	F 14-02-EL-01
2.4.4	**Car finishing. Stage P4** *Montajes de acabado. Posición P4*			I	
2.4.4.1	Hydraulic and pneumatic pipes assembly *Montaje de tubería hidraúlica y pneumática*	-	-	I	Q.41.FI.B022.01
2.4.4.2	Cabin conduits assembly & Electrical conduits preassembly *Montaje de conductos de cabina&Premontaje conductos eléctricos*	-	-	I	Q.41.FC.B084.01 Q.41.FI.B084.01
2.4.4.3	Eq. Cabin conduits *Equip. de conductos de cabina*	-	-	I	Q.41.FC.B084.02
2.4.4.4	Headstock installation + Cab Pneumatic piping assbly *Equipar cabecero + Montaje tubería neumática Cabina*	-	-	I	Q.41.FC.B025.01
2.4.4.5	Cab windows assembly *Montaje lunas de cabina*	-	-	I	Q.41.FC.B040.01 Q.41.FI.B040.01
2.4.4.6	Cab floor & Cabinets assembly *Montaje de armarios y pavimento en cabina*	-	-	I	Q.41.FC.B087.01 Q.41.FI.B087.01
2.4.4.7	Cab floor assembly *Montaje de pavimento en cabina*	-	-	I	F 14-02-EL-01
2.4.4.8	Connections checking *Control de conexionados*	-	-	I	Q.41.FC.B077.00 / 01 / 02
2.4.4.9	Equipped headstock inspection (before assbly in Carshell) *Inspección de cabecero equipado (antes de montar a Caja)*	-	-	I	F 14-02-EL-01
2.4.6	**Car finishing. Stage Z1** *Montajes de acabado. Posición Z1*			I	
2.4.6.1	Integration Car Phase1 (Carbody Assembly out of roof) *Integración de coche Fase1(Armar Caja excepto cubierta)*	-	-	I	Q.41.FC.B030.01 Q.41.FI.B030.01
2.4.6.2	Insulation preassembly *Premontaje de aislamientos*	-	-	I	Q.41.FC.B045.01
2.4.6.3	Insulation assembly *Montaje de aislamientos*	-	-	I	Q.41.FC.B045.02
2.4.6.4	Insulation + Floorpanels assembly *Montaje de tableros y aislamiento de piso*	-	-	I	Q.41.FC.B046.01
2.4.6.5	Floor inspection (before floorpanels fitment) *Inspección piso (antes montar tableros)*	-	-	I	F 14-02-EL-01
2.4.6.6	Floor panels assembly inspection *Inspección montaje tableros piso*	-	-	I	F 14-02-EL-01
2.4.6.7	Rubber floor covering assembly *Montaje pavimento*	-	-	I	Q.41.FC.B046.02 Q.41.FI.B046.02
2.4.6.8	Floor pavement fitment inspection - Z1 *Inspección Montaje pavimento - Z1*	-	-	I	F 14-02-EL-01
2.4.6.9	Footstep assembly *Montaje de peldaño*	-	-	I	Q.41.FC.B035.03
2.4.6.10	Dual Lock assembly *Montaje de Dual Locks*	-	-	I	Q.41.FC.B048.03 Q.41.FI.B048.03

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
2.4.6.11	Poliester Parts assembly *Montaje de piezas de Poliéster*	-	-	I	Q.41.FC.B048.05
2.4.6.12	Heaters+Convectors assembly *Montaje de calefactores y convectores*	-	-	I	Q.41.FC.B082.01
2.4.6.13	Windows assembly *Montaje de ventanas*	-	-	I	Q.41.FC.B040.02
2.4.6.14	Window assembly inspection *Inspección montaje ventanas*	-	-	I	F 14-02-EL-01
2.4.7	**Car finishing. Stage Z2** *Montajes de acabado. Posición Z2*			I	
2.4.7.1	Integration Car Phase2 (Roof Assembly) *Integración de coche Fase2 (Armar cubierta)*	-	-	I	Q.41.FC.B030.02 Q.41.FI.B030.02
2.4.7.2	Headstock, cabin and coupler assembly *Montaje de testero, cabina y enganche*	-	-	I	Q.41.FC.B033.01
2.4.7.3	Car fairings + Light assembly *Montaje de carenados y faros*	-	-	I	Q.41.FC.B033.02
2.4.7.4	Car integration inspection (roof permanently rivetted) *Inspección caja armada (techo fijado permanentemente)*	-	-	I	F 14-02-EL-01
2.4.7.5	In line watertightness local test *Prueba estanqueidad en Línea*	-	-	I	Q.41.90.100
2.4.7.6	Bellow and lower articulation assembly *Montaje de intercomunicación y Rótula*	-	-	I	Q.41.FC.B042.01 Q.41.FI.B042.01
2.4.7.7	Half articulation assembly inspection *Inspección montaje media articulación*	-	-	I	F 14-02-EL-01
2.4.7.8	Fire sealing *Sellado fuego*	-	-	I	Q.41.FC.B045.03
2.4.7.9	Underframe equipment (Uf.pneum+Hyd+Elec) assembly *Montaje aparatos B/B (pneumát+hid+elec)*	-	-	I	Q.41.FC.B022.01
2.4.7.10	Underframe piping (electrical, pneumatic & hidraulic) *Montaje tubería B/B (eléctrica, neumática e hidráulica)*	-	-	I	Q.41.FI.B022.01
2.4.7.11	Door leaves assembly *Montaje puertas*	-	-	I	Q.41.FC.B035.01
2.4.7.12	Side covers assembly *Montaje de carenados laterales*	-	-	I	Q.41.FC.B048.06
2.4.7.13	Side trapdoors assembly *Montaje de trampillas laterales*	-	-	I	Q.41.FC.B048.07
2.4.7.14	Interior equipment and passenger handrails assembly *Montaje aparatos interior de sala y asideros*	-	-	I	Q.41.FC.B074.01
2.4.7.15	Cab interiorism & partition lining assembly *Montaje interiorismo y revestimientos tabique*	-	-	I	Q.41.FC.B049.01
2.4.7.16	Connections checking *Control de conexionados*	-	-	I	Q.41.FC.B077.00 / 01 / 02
2.4.7.17	Underframe finishing inspection *Inspección acabados bajo bastidor*	-	-	I	F 14-02-EL-01
2.4.8	**Car finishing. Stage Z3** *Montajes de acabado. Posición Z3*			I	
2.4.8.1	Pneumatic & hidraulic pipes assembly *Montaje tubería neumática e hidráulica*	-	-	I	Q.41.FI.B022.01
2.4.8.2	Underframe insulation assembly *Montaje aislamiento bajo bastidor*	-	-	I	Q.41.FC.B045.04
2.4.8.3	Passenger Access doors Adjustment *Regulación puertas de Acceso Viajeros*	-	-	I	Q.41.FC.B035.02
2.4.8.4	Roof fairing assembly *Montaje carenado superior*	-	-	I	Q.41.FC.B031.01 Q.41.FI.B031.01
2.4.8.5	Side fairing and bogie skirts assembly *Montaje carenados laterales y faldones*	-	-	I	Q.41.FC.B031.02
2.4.8.6	Car fairings + Light assembly *Montaje carenados y faros*	-	-	I	Q.41.FC.B033.02

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
2.4.8.7	Exterior finishing inspection *Inspección acabados exterior*	-	-	I	F 14-02-EL-01
2.4.8.8	Upper articulation and damper assembly *Montaje articulación superior y amortiguador*	-	-	I	Q.41.FC.B042.02
2.4.8.9	Roof elec. equipment assembly *Montaje aparatos elect. en cubierta*	-	-	I	Q.41.FC.B073.02
2.4.8.10	Roof inspection *Inspección en cubierta*	-	-	I	F 14-02-EL-01
2.4.8.11	Saloon seats assembly *Montaje asientos de sala*	-	-	I	Q.41.FC.B052.01
2.4.8.12	Connections checking *Control de conexionados*	-	-	I	Q.41.FC.B077.00 / 01 / 02
2.4.8.13	Interior finishing inspection *Inspección acabados interior*	-	-	I	F 14-02-EL-01
2.4.9	**Car finishing. Stage Z3+ or Z0** *Montajes de acabado. Posición Z3+ o Z0*		I	I	
2.4.9.1	Get down car onto Trucks+Fixing+ Pneumat.Connec. *Bajar coche a bogie+Amarrar+Conex.neumat.*	-	-	I	Q.41.FC.B026.01 Q.41.FI.B026.01
2.4.9.2	Get down car onto Trucks+Fixing+ Pneumat.Connec. *Bajar coche a bogie+Amarrar+Conex.neumat.*	-	-	I	F 14-02-EL-01
2.4.9.3	Lower and Upper Articulation assembly inspection *Inspección montaje articulación superior e inferior*	-	-	I	F 14-02-EL-01
2.4.9.4	Rotatory platform assembly *Montaje plato giratorio*	-	-	I	Q.41.FC.B042.03
2.4.9.5	Obstacle deflector System assembly *Montaje Antiatrapapersonas*	-	-	I	Q.41.FC.B023.01
2.4.9.6	Finishing inspection complete Unit before testing *Inspección acabados Unidad completa antes pruebas*	-	-	I	F 14-02-EL-01
2.4.9.7	Main serial numbered Subsystems *Números de Serie elementos principales*	-	-	I	Q.41.90.500
2.4.9.8	Final finishing inspection complete Unit *Inspección final de acabados Unidad completa*	-	I	I	Q.41.90.122
2.4.9.9	Pre-Shipping Inspection *Inspección previa entrega*	-	-	I	Q.41.90.120
2.4.9.10	Post-Shipping Inspection (in Cincinnati) *Inspección tras entrega (en Cincinnati)*	-	-	I	Q.41.90.121
2.4.9.11	Final finishing inspection complete Unit after On Track testing (in Cincinnati) *Inspección final de acabados Unidad completa tras Pruebas Vía (en Cincinnati)*	-	-	I	Q.41.90.122
3	**TRUCKS MANUFACTURING AND TESTING PLAN**				
3.1	**TRUCK STRUCTURE MANUFACTURING** *FABRICACION DE ESTRUCTURA DE BOGIE*		I	I	
3.1.1	Assembly and welding: Truck frame *Armar y soldar Bastidor de Bogie*	-	-	I	MH1B250700
3.1.2	Brackets and console mounting *Montaje de soportes y consola*	-	-	I	MH1B250800
3.1.3	NDT: Truck frame welds *Verificación por END de soldaduras de Bastidor de Bogie*	-	I	I	M.H1.90.112
3.1.4	Bogie frame traceability of Casting pieces. Trazabilidad piezas fundición bastidor de Bogie	-	-	I	M.H1.90.101
3.1.5	Heat treatment verification: Truck frame *Verificación del tratamiento térmico de bastidor de bogie*	-	I	I	M.H1.90.102
3.1.6	Machining of Truck frame *Mecanizar Bastidor de Bogie*	-	-	I	MH1B250900

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
3.1.7	Dimensional control: Machined Truck frame *Verificación dimensional de Bastidor de Bogie mecanizado*	-	I	I	M.H1.90.103
3.1.8	Painting of Truck frame *Pintar bastidor de bogie*	-	-	I	MH1B251000
3.1.9	Painting inspection: Truck frame *Verificación de bastidor de bogie pintado*	-	I	I	M.H1.90.104
3.1.10	Dimensional control: Truck mounted bridge *Verificación dimensional de puente montado*	-	I	I	M.H1.90.105
3.2	**TRUCK FINISHING ASSEMBLY** *FABRICACIÓN ACABADO DE BOGIE*			I	
3.2.1	Primary suspension assembly *Montaje suspensión primaria*	-	-	I	*MH1B050100*
3.2.2	Secondary suspension assembly *Montaje suspensión secundaria*	-	-	I	*MH1B060100*
3.2.3	Engine assembly *Montaje del conjunto motorización*	-	-	I	*MH1B110100*
3.2.4	Brake equipment assembly Montaje de equipamiento de freno	-	-	I	*MH1B190100*
3.2.5	Electromagnetic brake assembly Montaje del freno electromagnetico	-	-	I	*MH1B200100*
3.2.6	Inscriptions assembly Montaje inscripciones	-	-	I	*MH1B570100*
3.2.7	Equipment of gear unit - motor subassemblies Montaje subconjuntos motor-reductor	-	-	I	*MH1A112001*
3.3	**TRUCKS FINAL TESTS** *PRUEBAS FINALES DE BOGIES*		I	I	
3.3.1	Serial numbers: Truck Parts *Identificación de Elementos bogie*	-	-	I	M.H1.90.106
3.3.2	Electric Resistance Verification *Verificación de Resistencia eléctrica*	-	-	I	M.H1.90.108
3.3.2	Electric Resistance Verification between wheels *Verificación de Resistencia eléctrica entre ruedas*	-	-	I	M.H1.90.113
3.3.3	Truck running test *Ensayo de rodaje*	-	-	I	M.H1.90.111
3.3.4	Truck under press test *Verificación bajo prensa*	-	-	I	M.H1.90.109
3.3.5	Pneumatic tightness under secondary suspension Verificación estanqueidad neumática bajo secundaria	-	-	I	M.H1.90.107
3.3.6	Final inspection: Finished Truck *Verificaciones finales de acabado de bogie completo*	-	I	I	M.H1.90.110
4	**FINAL INSPECTION AND TESTING PLAN: FACTORY TESTS AND ON TRACK TESTS**				
4.1	**FACTORY QUALIFICATION TESTS** *ENSAYOS TIPO FACTORÍA*				
4.1.1	Batterycapacity	I	-	-	Q.41.92.222.00
4.1.2	Traincontrol and monitoring system	I	-	-	Q.41.92.233.00
4.1.3	HMI fault verification	I	-	-	Q.41.92.234.00
4.1.4	Electrical Auxiliaries	I	-	-	Q.41.92.235.01
4.1.5	Passenger doors system	I	-	-	Q.41.92.241.00
4.1.6	Air balance	I	-	-	Q.41.92.251.01
4.1.7	Climatic room	I	-	-	Q.41.92.251.02
4.1.8	PISPASPA + CCTV system	I	-	-	Q.41.92.261.00
4.1.9	Event recorder	I	-	-	Q.41.92.263.00
4.1.10	Souplesse and wheel off-load	I	-	-	Q.41.92.275.20
4.1.11	Grounding and return circuits	I	-	-	Q.41.92.276.02
4.1.12	Ducting watertightness	I	-	-	Q.41.92.276.04

	INSPECTION				TEST FORM
	Designation	Qualification	FAI	Acceptance	
4.1.13	Gauging	I	-	-	Q.41.92.277.02
4.1.14	Curve negotiation	I	-	-	Q.41.92.277.03
4.1.15	Lightintensity	I	-	-	Q.41.92.278.20
4.1.16	Air leakage	I	-	-	Q.41.92.278.30
4.1.17	Emergency coupler	I	-	-	Q.41.92.291.00
4.2	**FACTORY ACCEPTANCE TESTS** *ENSAYOS SERIE FACTORÍA*				
4.2.1	Propulsion system	-	-	I	Q.41.92.501.00
4.2.2	Software versions	-	-	I	Q.41.92.525.00
4.2.3	Brake and leveling system	-	-	I	Q.41.92.532.00
4.2.4	Traincontrol and monitoring system	-	-	I	Q.41.92.233.00
4.2.5	Sand and lubrication system	-	-	I	Q.41.92.533.00
4.2.6	Electrical auxiliaries	-	-	I	Q.41.92.535.01
4.2.7	Electrical auxiliaries -safety	-	-	I	Q.41.92.535.02
4.2.8	Electrical auxiliaries -driving	-	-	I	Q.41.92.535.03
4.2.9	Passenger doors system	-	-	I	Q.41.92.541.00
4.2.10	HVAC	-	-	I	Q.41.92.551.00
4.2.11	PISPASPA + CCTV system	-	-	I	Q.41.92.561.00
4.2.12	Event recorder	-	-	I	Q.41.92.563.00
4.2.13	Insulation resistance and high potential	-	-	I	Q.41.92.572.00
4.2.14	Vehicle weight	-	-	I	Q.41.92.575.01
4.2.15	Grounding and return circuits	-	-	I	Q.41.92.576.02
4.2.16	Vehicle watertightness	-	-	I	Q.41.92.576.04
4.2.17	Vehicle leveling	-	-	I	Q.41.92.577.01
4.2.18	Overall dimensions	-	-	I	Q.41.92.578.01
4.2.19	Exterior lighting	-	-	I	Q.41.92.578.20
4.2.20	Obstacle deflector system	-	-	I	Q.41.92.594.00
4.3	**ON-TRACK QUALIFICATION TESTS** *ENSAYOS TIPO VÍA*				
4.3.1	Propulsion system	I/O*	-	-	Q.41.92.301.00
4.3.2	Thermal Capacity	I/O*	-	-	Q.41.92.323.00
4.3.3	Brake System	I/O*	-	-	Q.41.92.332.00
4.3.4	PISPASPA + CCTV System	I/O*	-	-	Q.41.92.361.00
4.3.5	EMC	I/O*	-	-	Q.41.92.375.10
4.3.6	Noise and Vibration	I/O*	-	-	Q.41.92.375.15
4.3.7	Ride quality and comfort	I/O*	-	-	Q.41.92.375.25
4.3.8	Lifting capability	I/O*	-	-	Q.41.92.377.40
4.3.9	Coupling capability	I/O*	-	-	Q.41.92.391.00
4.4	**ON-TRACK ACCEPTANCE TESTS** *ENSAYOS SERIE VÍA*				
4.4.1	Event Recorder	-	-	I/O*	Q.41.92.663.00
4.4.2	500 km operational test	-	-	I/O*	Q.41.92.679.01
4.4.3	Propulsion system	-	-	I/O*	Q.41.92.301.00
4.4.4	Brake System	-	-	I/O*	Q.41.92.332.00
4.4.5	Post-delivery test	-	-	I/O*	Q.41.92.679.02

I/O*: DETAILS OF LOCATION OF THE TEST AT THE OFFICIAL PROJECT SCHEDULE

ANNEX 2

LIST OF FAIs

1.2.1	MAIN EQUIPMENT EQUIPOS PRINCIPALES
1.2.1.1	PROPULSION SYSTEM SISTEMA DE TRACCIÓN
1.2.1.2	BRAKE RESISTOR RESISTENCIA DE FRENO
1.2.1.5	MASTER CONTROLLER MANIPULADOR DE TRACCIÓN
1.2.1.6	AUXILIARY POWER SUPPLY/ LOW VOLTAGE POWER SUPPLY/BATTERY CHARGER APS/LVPS/CARGADOR DE BATERÍAS
1.2.1.7	BATTERY BATERÍA
1.2.1.8	BRAKE SYSTEM SISTEMA DE FRENO
1.2.1.9	PASSENGER DOORS PUERTAS DE ACCESO VIAJEROS
1.2.1.10	HVAC AIRE ACONDICIONADO
1.2.1.11	PIS-PAS-PA SYSTEM&CCTV SISTEMA PIS-PAS-PA&CCTV
1.2.1.14	GANGWAY PASILLO INTERCIRCULACIÓN
1.2.1.15	GEARBOX REDUCTORA
1.2.1.16	LEVELING ACTUATOR ACTUADOR DE NIVELACIÓN
1.2.1.17	TRACTION MOTOR MOTOR DE TRACCIÓN
1.2.1.18	HEATERS CONVECTORES
1.3	**INSPECTION PLAN FOR THE REST OF PURCHASED MATERIALS** *PLAN DE INSPECCIÓN Y ENSAYOS PARA RESTO DE COMPONENTES DEL VEHÍCULO*
1.3.1	Front and Side Cab Glasses *Lunas de Cabina frontal y laterales*
1.3.2	Complete Cab Box (including fairings) Célula Completa (incluyendo carenados)
1.3.3	Door pillars Montantes poliéster
1.3.4	Desk Pupitre
1.3.5	Lighting Luminaria
1.3.6	Articulation Articulación
1.3.7	Saloon windows *Ventanas de Sala*
1.3.8	Passenger seats Asientos de Pasajeros
1.3.9	Driver´s Seat Asiento conductor
1.3.10	Floor panels Tableros
1.3.11	Floor covering Pavimento
1.3.12	HPL Interior linings Revestimientos interiores HPL
2.2	**TEST AND INSPECTION PLAN CARBODYSHELL STRUCTURE MANUFACTURING** *INSPECCION Y ENSAYOS EN FABRICACION DE LA CAJA*
2.2.2	Welding inspection: Cab headstock C Cars *Inspección soldadura de cabecero delantero Coches C*

2.2.3	Dimensional control: Cab headstock C Cars *Inspección dimensional de cabecero delantero coches C*
2.2.8	Welding inspection: Underframe C/S Cars *Inspección de soldaduras de bastidor de caja Coches C/S*
2.2.9	Dimensional control: Underframe C/S Cars *Inspección dimensional de bastidor de caja Coches C/S*
2.2.10	Underframe Control of riveting process C/S cars *Control proceso remachado bastidor Coches C/S*
2.2.11	Dimensional control: Roof C/S Cars *Inspección dimensional de cubierta Coches C/S*
2.2.12	Welding inspection: Roof C/R/S Cars *Inspección de soldaduras de cubierta Coches C/R/S*
2.2.15	Global control: Carbody - C/S Cars *Control general de caja - Coches C/S*
2.2.16	Dimensional control: Carbody C/S Cars *Inspección dimensional de caja Coches C/S*
2.2.17	Carbody: Control of riveting process *Control proceso remachado en caja.*
2.2.18	Carbody C/S (dimensional): Control in USA *Control Caja (dimensional) C/S en USA*
2.3	**BODYSHELL FINISHING. PAINTING PROCESS** *FABRICACION Y ACABADO DE CAJA. PROCESO DE PINTURA.*
2.3.2	Control of Carbodyshell painted *Control de caja pintada*
2.4	**BODYSHELL FINISHING AND ASSEMBLY** *FABRICACION Y ACABADO DE CAJA*
2.4.9	**Car finishing. Stage Z3+ or Z0** *Montajes de acabado. Posición Z3+ o Z0*
2.4.9.7	Final finishing inspection complete Unit *Inspección final de acabados Unidad completa*
3.1	**TRUCK STRUCTURE MANUFACTURING** *FABRICACION DE ESTRUCTURA DE BOGIE*
3.1.3	NDT: Truck frame welds *Verificación por END de soldaduras de Bastidor de Bogie*
3.1.5	Heat treatment verification: Truck frame *Verificación del tratamiento térmico de bastidor de bogie*
3.1.7	Dimensional control: Machined Truck frame *Verificación dimensional de Bastidor de Bogie mecanizado*
3.1.9	Painting inspection: Truck frame *Verificación de bastidor de bogie pintado*
3.1.10	Dimensional control: Truck mounted bridge *Verificación dimensional de puente montado*
3.3	**TRUCKS FINAL TESTS** *PRUEBAS FINALES DE BOGIES*
3.3.6	Final inspection: Finished Truck *Verificaciones finales de acabado de bogie completo*

ANNEX 3

LIST OF HOLD/WITNESS POINTS

	Designation	INSPECTION			H/W
		Qualification	FAI	Acceptance	
1.2.1	MAIN EQUIPMENT EQUIPOS PRINCIPALES				
1.2.1.1	PROPULSION SYSTEM SISTEMA DE TRACCIÓN	O	O	-	H
1.2.1.2	BRAKE RESISTOR RESISTENCIA DE FRENO	O	O	-	H
1.2.1.3	COMBINED TEST ENSAYO COMBINADO	O	-	-	H
1.2.1.5	MASTER CONTROLLER MANIPULADOR DE TRACCIÓN	O	O	-	H
1.2.1.6	AUXILIARY POWER SUPPLY/ LOW VOLTAGE POWER SUPPLY/BATTERY CHARGER APS/LVPS/CARGADOR DE BATERÍAS	O	O	-	H
1.2.1.7	BATTERY BATERÍA	-	O	-	H
1.2.1.8	BRAKE SYSTEM SISTEMA DE FRENO	O	O	-	H
1.2.1.9	PASSENGER DOORS PUERTAS DE ACCESO VIAJEROS	O	O	-	H
1.2.1.10	HVAC AIRE ACONDICIONADO	O	O	-	H
1.2.1.11	PIS-PAS-PA SYSTEM&CCTV SISTEMA PIS-PAS-PA&CCTV	O	O	-	H
1.2.1.12	EVENT RECORDER REGISTRADOR DE EVENTOS	O	-	-	H
1.2.1.14	GANGWAY PASILLO INTERCIRCULACIÓN	O	O	-	H
1.2.1.15	GEARBOX REDUCTORA	O	O	-	H
1.2.1.16	LEVELING ACTUATOR ACTUADOR DE NIVELACIÓN	O	I	-	H
1.2.1.17	TRACTION MOTOR MOTOR DE TRACCIÓN	O	O	-	H
1.2.1.18	HEATERS CONVECTORES	O	O	-	H
1.2.2	OTROS OTHERS				
1.2.2.1	CARBODY STRUCTURAL TEST ENSAYO ESTRUCTURAL DE CAJA	O	-	-	H
1.2.2.2	TRUCK STATIC AND FATIGUE TEST ENSAYO ESTÁTICO Y DE FATIGA DE BOGIE	O	-	-	H
1.2.2.3	FLOOR ASSEMBLY FIRE TEST ENSAYO DE FUEGO MONTAJE SUELO	O	-	-	H
1.2.2.4	ROOF ASSEMBLY FIRE TEST ENSAYO DE FUEGO MONTAJE TECHO	O	-	-	H
1.3	**INSPECTION PLAN FOR THE REST OF PURCHASED MATERIALS** *PLAN DE INSPECCIÓN Y ENSAYOS PARA RESTO DE COMPONENTES DEL VEHÍCULO*		O/I		
1.3.5	Lighting Luminaria	-	O/I	-	W
1.3.6	Articulation Articulación	-	O/I	-	W
1.3.8	Passenger seats Asientos de Pasajeros	-	O/I	-	W
1.3.9	Driver´s Seat Asiento conductor	-	O/I	-	W
1.3.12	HPL Interior linings Revestimientos interiores HPL	-	O/I	-	W

	Designation	INSPECTION			H/W
		Qualification	FAI	Acceptance	
2.2	**TEST AND INSPECTION PLAN CARBODYSHELL STRUCTURE MANUFACTURING** *INSPECCION Y ENSAYOS EN FABRICACION DE LA CAJA*		I	I	
2.2.2	Welding inspection: Cab headstock C Cars *Inspección soldadura de cabecero delantero Coches C*	-	I	I	W - FAI
2.2.3	Dimensional control: Cab headstock C Cars *Inspección dimensional de cabecero delantero coches C*	-	I	I	W - FAI
2.2.8	Welding inspection: Underframe C/S Cars *Inspección de soldaduras de bastidor de caja Coches C/S*	-	I	I	W - FAI
2.2.9	Dimensional control: Underframe C/S Cars *Inspección dimensional de bastidor de caja Coches C/S*	-	I	I	W - FAI
2.2.11	Dimensional control: Roof C/S Cars *Inspección dimensional de cubierta Coches C/S*	-	I	I	W - FAI
2.2.12	Welding inspection: Roof C/R/S Cars *Inspección de soldaduras de cubierta Coches C/R/S*	-	I	I	W - FAI
2.2.15	Global control: Carbody - C/S Cars *Control general de caja - Coches C/S*	-	I	I	W - FAI
2.2.16	Dimensional control: Carbody C/S Cars *Inspección dimensional de caja Coches C/S*	-	I	I	W - FAI
2.2.17	Carbody: Control of riveting process *Control proceso remachado en caja.*	-	I	I	W - FAI
2.2.18	Carbody C/S (dimensional): Control in USA *Control Caja (dimensional) C/S en USA*	-	I	I	W
2.3	**BODYSHELL FINISHING. PAINTING PROCESS** *FABRICACION Y ACABADO DE CAJA. PROCESO DE PINTURA.*		I	I	
2.3.2	Control of Carbodyshell painted *Control de caja pintada*	-	I	I	W - FAI
2.4	**BODYSHELL FINISHING AND ASSEMBLY** *FABRICACION Y ACABADO DE CAJA*		I	I	
2.4.2	**Car finishing. Stage P1** *Montajes de acabado. Posición P1*			I	
2.4.2.5	Control mounted subassemblies in electrical workshop (equiped driver desk + cabin cabinets + department panels + battery box) *Control de subconjuntos montados en Taller eléctrico (pupitres equipados + armarios de cabina + paneles departamento + cofre de batería)*	-	-	I	H-1st.Part
2.4.3	**Car finishing. Stage P3** *Montajes de acabado. Posición P3*			I	
2.4.3.5	Roof internal wiring inspection *Inspección cableado interior en cubierta*	-	-	I	H-1st. W-Rest
2.4.3.8	Roof inspection prior to assembly *Inspección cubierta previa a su montaje*	-	-	I	H
2.4.4	**Car finishing. Stage P4** *Montajes de acabado. Posición P4*			I	
2.4.4.7	Cab floor assembly *Montaje de pavimento en cabina*	-	-	I	H-1st. W-Rest
2.4.4.9	Equipped headstock inspection (before assbly in Carshell) *Inspección de cabecero equipado (antes de montar a Caja)*	-	-	I	H-1st.
2.4.6	**Car finishing. Stage Z1** *Montajes de acabado. Posición Z1*			I	
2.4.6.5	Floor inspection (before floorpanels fitment) *Inspección piso (antes montar tableros)*	-	-	I	H-1st.
2.4.6.6	Floor panels assembly inspection *Inspección montaje tableros piso*	-	-	I	H-1st.
2.4.6.8	Floor pavement fitment inspection - Z1 *Inspección Montaje pavimento - Z1*	-	-	I	H-1st. W-Rest
2.4.6.14	Window assembly inspection *Inspección montaje ventanas*	-	-	I	H-1st. W-Rest

	Designation	INSPECTION			H/W
		Qualification	FAI	Acceptance	
2.4.7	**Car finishing. Stage Z2** *Montajes de acabado. Posición Z2*			I	
2.4.7.4	Car integration inspection (roof permanently rivetted) *Inspección caja armada (techo fijado permanentemente)*	-	-	I	H
2.4.7.5	In line watertightness local test *Prueba estanqueidad en Línea*	-	-	I	H
2.4.7.7	Half articulation assembly inspection *Inspección montaje media articulación*	-	-	I	H-1st.
2.4.7.17	Underframe finishing inspection *Inspección acabados bajo bastidor*	-	-	I	H-1st. W-Rest
2.4.8	**Car finishing. Stage Z3** *Montajes de acabado. Posición Z3*			I	
2.4.8.7	Exterior finishing inspection *Inspección acabados exterior*	-	-	I	H-1st. W-Rest
2.4.8.10	Roof inspection *Inspección en cubierta*	-	-	I	H-1st. W-Rest
2.4.8.13	Interior finishing inspection *Inspección acabados interior*	-	-	I	H-1st. W-Rest
2.4.9	**Car finishing. Stage Z3+ or Z0** *Montajes de acabado. Posición Z3+ o Z0*		I	I	
2.4.9.2	Get down car onto Trucks+Fixing+ Pneumat.Connec. *Bajar coche a bogie+Amarrar+Conex.neumat.*	-	-	I	H-1st. W-Rest
2.4.9.3	Lower and Upper Articulation assembly inspection *Inspección montaje articulación superior e inferior*	-	-	I	H
2.4.9.7	Final finishing inspection complete Unit *Inspección final de acabados Unidad completa*	-	I	I	H
2.4.9.8	Pre-Shipping Inspection *Inspección previa entrega*	-	-	I	H
2.4.9.9	Post-Shipping Inspection (in Cincinnati) *Inspección tras entrega (en Cincinnati)*	-	-	I	H
2.4.9.10	Final finishing inspection complete Unit after On Track testing (in Cincinnati) *Inspección final de acabados Unidad completa tras Pruebas Vía (en Cincinnati)*	-	-	I	H
3	**TRUCKS MANUFACTURING AND TESTING PLAN**				
3.1	**TRUCK STRUCTURE MANUFACTURING** *FABRICACION DE ESTRUCTURA DE BOGIE*		I	I	
3.1.3	NDT: Truck frame welds *Verificación por END de soldaduras de Bastidor de Bogie*	-	I	I	W - FAI
3.1.7	Dimensional control: Machined Truck frame *Verificación dimensional de Bastidor de Bogie mecanizado*	-	I	I	W - FAI
3.3	**TRUCKS FINAL TESTS** *PRUEBAS FINALES DE BOGIES*		I	I	
3.3.1	Serial numbers: Truck Parts *Identificación de Elementos bogie*	-	-	I	H-1st. W-Rest
3.3.2	Electric Resistance Verification *Verificación de Resistencia eléctrica*	-	-	I	W - 1st
3.3.2	Electric Resistance Verification between wheels *Verificación de Resistencia eléctrica entre ruedas*	-	-	I	W - 1st
3.3.3	Truck running test *Ensayo de rodaje*	-	-	I	W - 1st
3.3.4	Truck under press test *Verificación bajo prensa*	-	-	I	W - 1st
3.3.5	Pneumatic tightness under secondary suspension Verificación estanqueidad neumática bajo secundaria	-	-	I	W - 1st
3.3.6	Final inspection: Finished Truck *Verificaciones finales de acabado de bogie completo*	-	I	I	H-FAI

	Designation	INSPECTION			H/W
		Qualification	FAI	Acceptance	
4	**FINAL INSPECTION&TESTING PLAN: FACTORY TESTS&ON TRACK TESTS**				
4.1	**FACTORY QUALIFICATION TESTS** *ENSAYOS TIPO FACTORÍA*				
4.1.1	Batterycapacity	I	-	-	W
4.1.2	Traincontrol and monitoring system	I	-	-	W
4.1.3	HMI fault verification	I	-	-	W
4.1.4	Electrical Auxiliaries	I	-	-	W
4.1.5	Passenger doors system	I	-	-	W
4.1.6	Air balance	I	-	-	W
4.1.7	Climatic room	I	-	-	W
4.1.8	PISPASPA + CCTV system	I	-	-	W
4.1.9	Event recorder	I	-	-	W
4.1.10	Souplesse and wheel off-load	I	-	-	W
4.1.11	Grounding and return circuits	I	-	-	W
4.1.12	Ducting watertightness	I	-	-	W
4.1.13	Gauging	I	-	-	W
4.1.14	Curve negotiation	I	-	-	W
4.1.15	Lightintensity	I	-	-	W
4.1.16	Air leakage	I	-	-	W
4.1.17	Emergency coupler	I	-	-	W
4.2	**FACTORY ACCEPTANCE TESTS** *ENSAYOS SERIE FACTORÍA*				
4.2.1	Propulsion system	-	-	I	W
4.2.2	Software versions	-	-	I	W
4.2.3	Brake and leveling system	-	-	I	W
4.2.4	Traincontrol and monitoring system	-	-	I	W
4.2.5	Sand and lubrication system	-	-	I	W
4.2.6	Electrical auxiliaries	-	-	I	W
4.2.7	Electrical auxiliaries -safety	-	-	I	W
4.2.8	Electrical auxiliaries -driving	-	-	I	W
4.2.9	Passenger doors system	-	-	I	W
4.2.10	HVAC	-	-	I	W
4.2.11	PISPASPA + CCTV system	-	-	I	W
4.2.12	Event recorder	-	-	I	W
4.2.13	Insulation resistance and high potential	-	-	I	W
4.2.14	Vehicle weight	-	-	I	W
4.2.15	Grounding and return circuits	-	-	I	W
4.2.16	Vehicle watertightness	-	-	I	W
4.2.17	Vehicle leveling	-	-	I	W
4.2.18	Overall dimensions	-	-	I	W
4.2.19	Exterior lighting	-	-	I	W
4.2.20	Obstacle deflector system	-	-	I	W
4.3	**ON-TRACK QUALIFICATION TESTS** *ENSAYOS TIPO VÍA*				
4.3.1	Propulsion system	I/O*	-	-	W
4.3.2	Thermal Capacity	I/O*	-	-	W
4.3.3	Brake System	I/O*	-	-	W
4.3.4	PISPASPA + CCTV System	I/O*	-	-	W

	Designation	INSPECTION			H/W
		Qualification	FAI	Acceptance	
4.3.5	EMC	I/O*	-	-	W
4.3.6	Noise and Vibration	I/O*	-	-	W
4.3.7	Ride quality and comfort	I/O*	-	-	W
4.3.8	Lifting capability	I/O*	-	-	W
4.3.9	Coupling capability	I/O*	-	-	W
4.4	**ON-TRACK ACCEPTANCE TESTS** *ENSAYOS SERIE VÍA*				
4.4.1	Event Recorder	-	-	I/O*	W
4.4.2	500 km operational test	-	-	I/O*	W
4.4.3	Propulsion system	-	-	I/O*	W
4.4.4	Brake System	-	-	I/O*	W
4.4.5	Post-delivery test	-	-	I/O*	W

ANNEX 4

PRE-SHIPMENT INSPECTION

EDITION CONTROL / *CONTROL DE EDICIÓN*

EDITION *EDICIÓN*	REASON *MOTIVO*	DATE *FECHA*
-	1st edition - *1ª edición*	10/10/2014
A	Updated acc. customer comments CINCAF756	08/04/2015
B	Pantograph & rubber part of Deflector dismounted	06/10/2015

DISTRIBUTION / *DISTRIBUCIÓN*

Engineering project manager Jefatura de proyecto Oficina Técnica
Engineering finishing area project manager Jefatura de proyecto area acabados Oficina Técnica
Project Manager Gerencia de Proyecto
Manufacturing Engineering manager Responsable de Ingeniería de Producción
Quality project manager Responsable de Calidad de Proyecto
Manufacturing Quality manager Responsable de Calidad de Fabricación
Manufacturing manager Responsable de Pruebas

Confeccionado/ *Prepared by:*	Revisado / *Revised by:*	Aprobado/ *Approved:*
Nombre/ *Name:* M.Artigas Firma/ *Signature*: Fecha/ *Date*: 06.10.2015	Nombre/ *Name:* D.Novellón Firma/ *Signature*: Fecha/ *Date*: 06.10.2015	Nombre/ *Name:* D.Paricio Firma/ *Signature*: Fecha/ *Date*: 06.10.2015

Vehicle number	

Car/Module serial numbers		
C1	S1	C2

Equipment On Board:

Item	C1	S1	C2	OK	NOK
Pantograph crank			X	☐	☐

Fixed Elements:

Item	C1	S1	C2	OK	NOK
Pantograph dismounted			X	☐	☐
Roof boxes closed	X	X	X	☐	☐
Roof fairings closed	X	X	X	☐	☐
Coupler C1 retracted	X			☐	☐
Coupler C2 retracted			X	☐	☐
Coupler covers secured	X		X	☐	☐
Obstacle deflector fixed in highest position; rubber dismounted.	X		X	☐	☐
Brakes set to proper position	X		X	☐	☐
Truck skirts closed	X		X	☐	☐
Sand ejectors in highest position	X		X	☐	☐
Cabinets locks closed	X		X	☐	☐
Driver desk door closed	X		X	☐	☐
Driver cab door locked	X		X	☐	☐
Passenger doors locked (latched) and cannot be pushed open	X	X	X	☐	☐
All the elements disassembled to transport (according transport instruction of the project) fixed properly	X	X	X	☐	☐
In case of delivery of the Unit in 2 semi-Units, check that lower Articulation has a jig to avoid be suspended during transportation.		X		☐	☐

Others:

Item	C1	S1	C2	OK	NOK
Main battery switch off	X			☐	☐

Operator* /** ***Operario: ***Signature* / *Firma:*** ***Date* / *Fecha:***	**Manufacturing Resp. /** **Resp. Sección:** ***Signature* / Firma:** **Date / Fecha:**
Quality Resp./ ***Resp. Calidad:*** ***Signature / Firma:*** ***Date / Fecha:***	***Customer Repr. /*** ***Repr. Cliente:*** ***Signature / Firma:*** ***Date / Fecha:***

The list of equipments is to be considered as a minimum representation. If additional equipment requires inspection, or quality issues are discovered during the pre-shipment phase of the first unit, it will be added to the procedure list In case of any outstanding point mark as “Pending” and explain below. Once corrected mark “OK” in the corresponding line.
If any further explanation is needed, indicate in “Comments”.

Comments:

Operator / ***Operario:*** ***Signature / Firma:*** ***Date / Fecha:***	**Manufacturing Resp. /** **Resp. Sección:** ***Signature* / Firma:** **Date / Fecha:**
Quality Resp./ ***Resp. Calidad:*** ***Signature / Firma:*** ***Date / Fecha:***	***Customer Repr. /*** ***Repr. Cliente:*** ***Signature / Firma:*** ***Date / Fecha:***

ANNEX 5

POST-SHIPMENT INSPECTION

EDITION CONTROL / *CONTROL DE EDICIÓN*

EDITION *EDICIÓN*	REASON *MOTIVO*	DATE *FECHA*
-	1st edition - *1ª edición*	10/10/2014
A	Updated acc. customer comments CINCAF756	09/04/2015
B	Pantograph & rubber part of Deflector Assembly	06/10/2015

DISTRIBUTION / *DISTRIBUCIÓN*

Engineering project manager Jefatura de proyecto Oficina Técnica
Engineering finishing area project manager Jefatura de proyecto area acabados Oficina Técnica
Project Manager Gerencia de Proyecto
Manufacturing Engineering manager Responsable de Ingeniería de Producción
Quality project manager Responsable de Calidad de Proyecto
Manufacturing Quality manager Responsable de Calidad de Fabricación
Manufacturing manager Responsable de Pruebas

Confeccionado/ *Prepared by:*	Revisado / *Revised by:*	Aprobado/ *Approved:*
Nombre/ *Name:* M.Artigas	Nombre/ *Name:* D.Novellón	Nombre/ *Name:* D.Paricio
Firma/ *Signature*:	Firma/ *Signature*:	Firma/ *Signature*:
Fecha/ *Date*: 06.10.2015	Fecha/ *Date*: 06.10.2015	Fecha/ *Date*: 06.10.2015

Vehicle number	

Car/Module serial numbers		
C1	S1	C2

Fixed for transport Elements:

Item	C1	S1	C2	OK	NOK
Release sand ejectors to functional height	X		X	☐	☐
Release brakes	X		X	☐	☐
Release obstacle deflector C1 to functional height. Rubber assbly.	X			☐	☐
Release obstacle deflector C2 to functional height. Rubber assbly.			X	☐	☐
Assemble again all the elements disassembled to transport (according transport instruction of the project). E.g. pantograph	X	X	X	☐	☐
In case of delivery of the Unit in 2 semi-Units, assemble the lower articulation (after assembly, remove jig of the lower Articulation)		X		☐	☐

Others:

Item	C1	S1	C2	OK	NOK
Assembly pantograph			X	☐	☐
Walk around vehicle and visually Inspect the condition of the Exterior wrapping for any apparent shipping damage prior to unloading from shipping trailers.	X	X	X	☐	☐
Remove any components that may obstruct or become damaged during unloading of the streetcar.	X	X	X	☐	☐
Visually inspect the streetcar Exterior for any shipping damage.	X	X	X	☐	☐
Visually inspect the Roof and roof equipment for any shipping damage.	X	X	X	☐	☐
Visually inspect Underframe for any damage during shipment and unloading.	X	X	X	☐	☐
Visually inspect passenger area interiors for any shipping damage.	X	X	X	☐	☐
Visually inspect both cabs interiors for any shipping damage.	X		X	☐	☐

In case of any outstanding point mark as "Pending" and explain below. Once corrected mark "OK" in the corresponding line. If any further explanation is needed, indicate in "Comments".

Comments:

___

___

___

Operator* / *Operario:* *Signature* / *Firma:* *Date* / *Fecha:	**Manufacturing Resp. / Resp. Sección: *Signature* / Firma: Date / Fecha:**
Quality Resp./ Resp. Calidad: Signature / Firma: Date / Fecha:	***Customer Repr. / Repr. Cliente: Signature / Firma: Date / Fecha:***

ANNEX 6

CAF&CUSTOMER FINAL INSPECTION

CONTROL DE EDICIÓN
ISSUE CONTROL

Edición *ISSUE*	MOTIVO *CONCEPT*	FECHA *DATE*
-	1ª Edición / *1st Edition*	16/OCT/2014
A	Included tightening and torque mark of support assembly item 11 of M.H1.06.000/200	18/NOV/2014

"Toda copia impresa de este documento sin el sello tampón en tinta roja de "Copia Controlada", es una "COPIA NO CONTROLADA", debiéndose consultar en BDI su última edición"

Confeccionado/ *Prepared by:*	Revisado / *Reviewed by:*	Aprobado / *Approved by:*
Nombre / *Name*: Marcos López Fecha / *Data*: 18/NOV/2014 Firma /*Sign*:	Nombre / *Name*: Miguel Artigas Fecha / *Data*: 18/NOV/2014 Firma / *Sign*:	Nombre / *Name*: David Paricio Fecha / *Data*: 18/NOV/2014 Firma / *Sign*:

	FINAL FINISHING VERIFICATION VERIFICACIÓN FINAL ACABADO	Q.41.90.122	A
		Pág. 2 de 3 Page 2 of 3	

Streetcar identification number		**Car / module serial numbers**		
Before shipping		**C1**	**S1**	**C2**
After track tests				

	OK	**NO OK**
General Cleaning of Cab and Passenger Area (Dirt, Trash, Remain of Tape)* *Limpieza General de Cabina y Zona de Pasajeros (Suciedad, Basura, Restos de Cinta)**		
Cleaning in Electrical Lockers, interior of Trapdoors and Cab Desk (Metallic particles, Dust, Trash)* *Limpieza en armarios eléctricos y cofres (Partículas metálicas, Polvo, Basura)**		
Internal Finishing (Lining: No damage. Floor Covering: cleaning, sealing, Gangway: No gaps or torn. Seating: No scratches or damage, fixing. Trapdoors and Lockers: Correct operation)* *Acabado Interior (Revestimientos sin daños. Pavimento: limpieza y sellado. Pasillo: Sin huecos o desgarros. Asientos sin rayas o daños, fijación. Trampillas y Cierres: Funcionamiento correcto.)**		
Handrails (Mounting rigidity, absence of sharp edges)* *Pasamanos (Rigidez de montaje, ausencia de bordes cortantes)**		
Cab Finishing (Driver Desk: no damage, correct Equipment adjustment, Doors opening, lockers, Lighting, Wipes)* *Acabado de Cabina (Pupitre sin daños, Ajuste correcto de Equipos, apertura de Puertas, Cierres, Iluminación, Cortinillas)**		
External Finishing (No Paint damage, Underframe and Roof Cleaning, Front Trapdoor operation, Skirts adjustment)* *Acabado Exterior (Pintura sin daños, Limpieza de Cubierta y Bajo Bastidor, funcionamiento de Trampilla frontal, ajuste de Faldones)**		
Sealing (Exterior: Rear Endplate, Gangway)* *Sellados (Exterior: Testero Trasero, Pasillo)**		
Right Screws and Fasteners, tightening and torque mark acc. to CAF specification W.00.00084 (Check Roof equipment, Skirts and Couplers acc.drawing; Grounding acc. N-10.11-BZ-04; item 11 of M.H1.06.000/200 acc. drawing …)* *Marcaje de tornillería y pares de apriete correctos según especificación CAF W.00.00084 (Revisar Equipos en Techo, Carenados y Enganches s/plano, Puestas a Tierra s/ N-10.11-BZ-04; marca11 de M.H1.06.000/200 s/plano...)**		
Interior Lighting (Operation check: Passenger Area lights, Doors lights, Emergency lights)* *Iluminación interior (Verificación de funcionamiento: Iluminación Área Pasajeros, Iluminación Puertas, Luces Emergencia)**		
Exterior Lighting (Operation check: Headlights, Side lights, Clearance lights)* *Iluminación exterior (Verificación de funcionamiento: Faros, Iluminación lateral, Luces Gálibo)**		

OPERADOR / ***Operador*** **Firma / *Signature*:** **Fecha / *Date*:**	**R. SECCION /** ***Manufacturing Repr.*** **Firma / *Signature*:** **Fecha / *Date* :**
R. CALIDAD ***Q.A. Representative*** **Firma / *Signature* :** **Fecha / *Date*:**	**R. CLIENTE /** ***Customer Repr.*** **Firma/ *Signature*:** **Fecha / *Date*:**

Streetcar identification number		**Car / module serial numbers**		
Before shipping		**C1**	**S1**	**C2**
After track tests				

	OK	**NO OK**
Maintenance consumables (Levels of Gear Unit oil, Windshield washer, Sanding)* *Consumibles mantenimiento (Niveles de aceite en Reductora, Agua del Limpia, Arena)**		
Coupling Carshell / Truck (Hydraulic piping, Electrical connections, lack of interferences)* *Acoplamiento Caja / Bogie (Tubería Hidráulica, Conexiones eléctricas, ausencia de interferencias)**		
Protection against corrosion (Not painted areas)* *Protección contra la corrosión (Zonas no pintadas)**		
Interior Signs (according to Q.41.56.100, Q.41.56.120)* *Inscripciones interiores (de acuerdo a Q.41.56.100, Q.41.56.120)**		
Exterior Signage (according to Q.41.57.100, Q.41.57.120)* *Inscripciones exteriores (de acuerdo a Q.41.57.100, Q.41.57.120)**		
Electric Risk Signage (COMPAC, Brake Resistors, HSCB, HVAC)* *Señalización de Riesgo eléctrico (COMPAC, Resistencias de Freno, Disyuntor, Aire Acondicionado)**		
Furnishings (according to Q.41.63.106 / Q.41.63.139)* *Dotación (de acuerdo a Q.41.63.106 / Q.41.63.139)**		
Cab Fire Extinguisher (according to Q.41.63.100)* *Extintor de Cabina (de acuerdo a Q.41.63.100)**		

*** In case of any outstanding point mark as "Pending" and explain below. Once corrected mark "OK" in the corresponding line. If any further explanation is needed, indicate in "Comments".**

** En caso de existir algún punto pendiente marcar "Pendiente" y explicar debajo. Una vez corregido marcar "OK" en la línea correspondiente. En caso de ser necesario algún comentario adicional, indicarlo en el cuadro "Observaciones".*

COMMENTS / *OBSERVACIONES*

OPERADOR / ***Operador*** **Firma / *Signature*:** **Fecha / *Date*:**	**R. SECCION /** ***Manufacturing Repr.*** **Firma / *Signature*:** **Fecha / *Date* :**
R. CALIDAD ***Q.A. Representative*** **Firma / *Signature* :** **Fecha / *Date*:**	**R. CLIENTE /** ***Customer Repr.*** **Firma/ *Signature*:** **Fecha / *Date*:**

ANNEX 7

MATRIX - INSPECTION AND TESTING PLAN

INDEX – ANNEX7

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

PROJECT / *PROYECTO* : **Cincinnati Streetcar**

ANNEX 7 - Q.41.96.902	
Issue/ *Edición:*	Project code/ *Clave de obra*
F	2317

city of CINCINNATI OFFICE OF THE CITY MANAGER

Item *Item*	Designation *Denominación*	Supplier *Suministrador*	Control Type: Qualif. *Tipo*	Control Type: FAI *FAI*	Control Type: Accept. *Serie*	Control Specification *Especificación de Control*	Responsible *Responsable*	Frequency *Frecuencia*	Customer Presence *Presencia cliente*	Records: Document *Documento*	Records: Customer delivery *Entrega a cliente*
1	**TEST AND INSPECTION PLAN FOR INCOMING GOODS -** *PLAN DE INSPECCION Y ENSAYOS EN RECEPCION*										
1.1	**GENERAL INCOMING MATERIALS INSPECTION ACCORDING TO P-11.03-BZ** **INSPECCION EN RECEPCION GENERAL SEGÚN PROCEDIMIENTO P-11.03-BZ**	CAF	-	-	I		C	Acc. to P-11.03-BZ	-	-	-
1.1.1	Chapas y perfiles de acero laminados en caliente, que incluye barras perforadas, redondos, exágonos, llantas, etc. Plates and hot-rolled steel sections that include perforated bars, round bars, hex-sided sections, rims, etc…	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.2	Chapas y perfiles de acero laminados en frío. Cold rolled steel sections and plate work.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.3	Chapas y perfiles de acero inoxidable Stainless steel sections and plate work.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.4	Chapas, perfiles y chapas perforadas en metales no férreos (excepto aluminio) Non-ferrous metal (not aluminium) plates, sections and perforated plates	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.5	Chapas, perfiles y chapas perforadas en aluminio Aluminium plates, sections and perforated plates	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.6	Piezas fundidas de acero Steel castings	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.7	Piezas fundidas de acero destinadas a bogies, reductoras, tracción, choque y estructura resistente de bogie y caja Steel castings for bogies, gear units, traction systems, buffing and bogie and carbody resistant structure	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.8	Piezas forjadas o estampadas de acero o de aluminio Steel or aluminium forged or stamped parts.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.9	Piezas forjadas o estampadas, de acero, o de aluminio, destinadas a bogies, reductoras, tracción, choque y estructura resistente de Bogie o Caja. Steel or aluminium forged or stamped parts for bogies, gear units, traction systems, buffing and bogie and carbody resistant structure.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.10	Piezas embutidas u oxicortadas, de acero o de aluminio Steel or aluminium deep drawn or flamecut parts.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.11	Piezas embutidas u oxicortadas, de acero o de aluminio, destinadas a estructura resistente de Bogie o Caja Steel or aluminium deep drawn or flamecut parts for bogie and carbody resistant structure	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.12	Piezas embutidas u oxicortadas, de acero o de aluminio, destinadas a grúas Steel or aluminium deep drawn or flamecut parts for cranes.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.13	Piezas mecanizadas de acero o de aluminio Steel or aluminium machined parts.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

PROJECT / *PROYECTO* : Cincinnati Streetcar

ANNEX 7 - Q.41.96.902	
Issue/ *Edición:*	**Project code/** *Clave de obra*
F	2317

city of CINCINNATI
OFFICE OF THE CITY MANAGER

Item *Item*	Designation *Denominación*	Supplier *Suministrador*	Control Type: Qualif. *Tipo*	Control Type: FAI *FAI*	Control Type: Accept. *Serie*	Control Specification *Especificación de Control*	Responsible *Responsable*	Frequency *Frecuencia*	Customer Presence *Presencia cliente*	Records: Document *Documento*	Records: Customer delivery *Entrega a cliente*
1.1.14	Piezas mecanizadas, de acero o de aluminio, destinadas a Bogie y unión Caja-Bogie, (barra de torsión, coronas de orientación, pivote, biela de arrastre). Piezas de acero con exigencias referentes a Carbono equivalente. Steel or aluminium machined parts for bogies and Carbody-Bogie links, (torque arm, centre bearing, pivot, drag link). Steel parts with requirements regarding equivalent Carbon content.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.15	Piezas mecanizadas fundidas de acero o aluminio destinadas a Bogies, Reductoras, Tracción, Choque y Estructura resistente a Bogie y Caja. Cast steel or aluminium machined parts for Bogies, Gear Units, Traction, Buffing and resistant structure of Bogies and Carbodies.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.16	Piezas mecanizadas forjadas o estampadas, de acero o aluminio, destinadas a estructura resistente de Bogie y Caja Steel or aluminium forged or stamped parts for bogie and carbody resistant structures	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.17	Conjuntos, subconjuntos y piezas de calderería en acero Assemblies, subassemblies and steel platework parts.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.18	Conjuntos, subconjuntos y piezas de calderería en acero para estructura resistente de Bogie y Caja y canales de Aire Acondicionado. Steel plate work assemblies, subassemblies and parts for Bogie and carbody resistant structures and Air Conditioning ductwork.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.19	Conjuntos, subconjuntos y piezas de calderería en metales no férreos Non ferrous metal plate work assemblies, subassemblies and parts.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.20	Conjuntos, subconjuntos y piezas de calderería de aluminio para estructura resistente de Bastidor y Caja y canales de Aire Acondicionado. Aluminium plate work assemblies, subassemblies and parts for Bogie and carbody resistant structures and Air Conditioning ductwork.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.21	Tornillería general General fixings	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.22	Tornillos y tuercas, bajo plano Fasteners and nuts, under specified plane	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.23	Tornillería, tuercas estructurales y/o seguridad Fixings, structural and/or safety nuts	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.24	Tuberías Pipework	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.25	Tubería de acero Steel piping	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.26	Tubería resto materiales Piping of other materials	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-

CAF CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.	INSPECTION AND TESTING PLAN PLAN DE INSPECCIÓN Y ENSAYOS PROJECT / PROYECTO : Cincinnati Streetcar							ANNEX 7 - Q.41.96.902		City of CINCINNATI OFFICE OF THE CITY MANAGER	
								Issue/ Edición:	Project code/ Clave de obra		
								F	2317		
			Control Type							Records	
Item *Item*	Designation Denominación	Supplier *Suministrador*	Qualif. *Tipo*	FAI *FAI*	Accept. *Serie*	Control Specification *Especificación de Control*	Responsible *Responsable*	Frequency *Frecuencia*	Customer Presence *Presencia cliente*	Document *Documento*	Customer delivery *Entrega a cliente*
1.1.27	Tubería eléctrica Electric piping	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.28	Accesorios para todas las tuberías: racores, adaptadores, mangueras sin plano (tubo goma), bridas, abrazaderas, prensaestopas, etc. Accessories for all piping: fittings, adaptors, standard hoses (rubber tube), flanges, clamps, cable glands, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.29	Rodamientos Rolling Bearings	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.30	Rodamientos destinados a caja de grasa y reductoras Bearings for axle boxes and gear units	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.31	Muelles: 1. Helicoidales 2. De ballesta suspensión bogie 3. De barra de torsión Springs: 1. Coil type 2. Bogie suspension plate spring 3. Twist bar type	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.32	Piezas de goma: juntas, anillos, pasacables, rellenos, etc. Rubber parts: seals, rings, grommets, padding, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.33	Perfiles de goma para marcos de ventana y de puertas, tanto exteriores como interiores Rubber sections for exterior and interior window and door frames	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.34	Paneles rellenos de madera, tableros en general Panels filled with wood, boards in general	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.35	Paneles de piso y tableros con exigencias similares Floor panels and boards with similar requirements	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.36	Plásticos (inyectados, moldeados, etc.), poliésteres, resinas, PVC, similares, etc. Plastics (injected, moulded, etc.), polyesters, resins, PVC, similar materials, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.37	Plásticos. Piezas interiores y exteriores de plástico reforzado con fibra de vidrio (PRFV) Plastics. Fibreglass-reinforced interior and exterior plastic parts (PRFV)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.38	Tapicería, fundas y rellenos de asientos y camas, telas, moquetas, cortinas, etc. acopiadas sin confeccionar Seat and bed upholstery, covers and padding, fabrics, carpets, curtains, etc. bought untailored	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-

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1.1.39	Elementos y conjuntos de acabado acopiados terminados del exterior: > Lunas y ventanas (20.1.) > Mecanismos de puertas interiores y exteriores sueltos (habitualmente van incluidos en equipo mecanismos de puertas). (20.2.) > Puertas interiores y exteriores (20.3.) > Mesas, armarios, muebles, etc. (20.3.) > Frigoríficos, cocinas, microondas, cafeteras, lavavajillas, etc. (20.3.) Exterior finish elements and assemblies bought completed: - Windows and Glazing (20.1). - Separate interior and exterior door mechanisms (normally included in the door mechanisms equipment). (20.2.) - Interior and exterior doors. (20.3) - Tables, cabinets, furniture, etc. (20.3.) - Refrigerators, hot plates, microwaves, coffee machines, dish washers. etc. (20.3.)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.40	Lunas templadas y/o laminadas (de seguridad), para costados de caja, testero de cabina, tabiques, maleteros, ventanas de puertas, etc. Hardened glass panels and/or laminated glass panels (for safety), B47for carbody sides, cab body ends, partitions, luggage areas, door windows, etc. Ventanas completas Complete windows	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.41	Mecanismos de puertas exteriores e interiores (sueltos, no equipos) - Exterior and Interior door mechanisms (single units, not the whole equipment).	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.42	Puertas interiores y exteriores Asientos, camas, parasoles, cortinas, etc. Mesas, armarios, muebles, etc. Frigoríficos, cocinas, cafeteras, lavavajillas, microondas Interior and exterior doors. - Seats, beds, sun shades, curtains, etc. - Tables, cabinets, furniture, etc. - Refrigerators, hot plates, coffee machines, dish washers, microwaves	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.43	Cerraduras, bisagras, etc. según plano. Locks, hinges, etc. according to drawing.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.44	Pinturas, imprimaciones, esmaltes, barnices, etc. Paints, primers, enamels, varnishes, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-

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1.1.45	Equipos eléctricos comprados por CAF: - Equipo eléctrico principal, calefacción, megafonía, telefonía, ASFA, repetición de señales, HASLER, señalización, TV-Vídeo, SIV, ATP, etc. Electrical equipment bought by CAF: Main electrical equipment, heating, PA system, telephone system, ASFA, signal repetition, HASLER, signalling, TV-Video, SIV, ATP, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.46	Componentes sueltos de restantes equipos comprados por CAF en familia 44: - Manómetros, termómetros, vacuómetros, válvulas, depósitos, contenedores, mangueras con plano, amortiguadores comerciales, etc. Single parts of remaining equipment bought by CAF in product family 44: - Pressure gauges, thermometers, vacuum gauges, valves, tanks, containers, hoses with drawings, off the shelf dampers, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.47	Depósitos de presión / Pressure tanks	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.48	Baterías / Batteries	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.49	Componentes y aparatos de los Equipos Eléctricos comprados por CAF en familia 23, como: Aparellaje eléctrico (relés, contactores, conectores, interruptores, manipulador, conmutadores, pulsadores, etc. Aparatos de alumbrado (plafones, difusores, leedoras, faros, señales de cola, etc.) Components and apparatus of the Electrical Equipment bought by CAF in product family 23, such as: - Electrical gear (relays, contactors, connectors, circuit breakers, handles, selector switches, buttons, etc. - Lighting apparatus (soffits, diffusers, reading lamps, head lamps, tail lights, etc.)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.50	Material para instalaciones eléctricas: cintas, fusibles, enchufes, regletas, aisladores, terminales, canalizaciones, etc. Material for electrical installations: Tapes, fuses, power outlets, terminal bars, insulators, cable end fittings, ducting, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.51	Cables	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.52	Equipos y elementos aportados del exterior, por Clientes/Socios/Colaboradores, no comprados por CAF Equipment and items provided externally by Customers/Partners/Collaborators, not purchased by CAF.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.53	Pavimentos de goma y de plástico. Moquetas Rubber and plastic flooring. Carpets	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

PROJECT / *PROYECTO* : Cincinnati Streetcar

ANNEX 7 - Q.41.96.902

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city of CINCINNATI OFFICE OF THE CITY MANAGER

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1.1.54	Piezas fundidas de aluminio o metales no férreos (excluidos herrajes, metalistería y recubrimientos Aluminium or non-ferrous metal castings (excluding ironwork fittings, metal carpentry and coatings.)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.55	Piezas fundidas de aluminio o metales no férreos destinadas a bogie y armadura resistente de Bastidor o Caja. Aluminium or non-ferrous metal castings for bogies and resistant Undercar or Carbody framing.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.56	Bulones y casquillos Pins and bushings	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.57	Bulones y casquillos especiales que forman parte de elementos de seguridad Special pins and bushings that form part of the safety elements.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.58	Aislamientos no eléctricos y Estratificados Layered and non.electrical insulation	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.59	Aislamientos no eléctricos (fibra de vidrio, lana de roca, nido de abeja, etc.) Non-electrical insulation (fibre glass, rock wool, honeycombed structure, etc.)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.60	Estratificados (Laminados decorativos de alta presión: formica, tablex, railite, aglomerados, melaminas, etc.) Layered (High pressure decorative laminates: formica, tablex, railite, aggregates, melamines, etc)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.61	Aislamientos eléctricos (baquelita, mica, etc.) Electric insulation (bakelite, mica, etc.)	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.62	Vidrio, cristales, espejos, etc., sin templar ni laminar. Glass, glazing, mirrors, etc., neither tempered nor laminated.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.63	Inscripciones, anagramas, logotipos, placas, pegatinas, etc. Inscriptions, anagrams, logotypes, badges, stickers, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.64	Adhesivos, pegamentos, siliconas, etc. Sealants, glues, silicones, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.65	Grasa, aceites, combustibles, anticongelantes, anticorrosivos, etc. Grease, oils, fuels, antifreezes, anticorrosive, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.66	Grasas de rodamientos y aceites de reductoras Bearing greases and gear unit oils	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

PROJECT / PROYECTO : Cincinnati Streetcar

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city of CINCINNATI OFFICE OF THE CITY MANAGER

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1.1.67	Piezas de caucho-metal 1. Silentblocks, flexiblocks, articulaciones 2. Muelles batra-estrella, muelles de caucho 3. Muelles de goma para Bogies Clouth 4. Muelle neumático de goma suspensión secundaria 5. Amortiguadores de Bogie Rubber-metal parts: 1. Silentblocks, flexiblocks, joints 2. Bar-Star springs, rubber springs 3. Rubber springs for Clouth Bogies 4. Secondary suspension pneumatic rubber spring 5. Bogie dampers	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.68	Elementos de ferretería Hardware fixings	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.69	Pasamanos, asideros, ceniceros, etc. Handrails, handgrips, ashtrays, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.70	Herramientas de dotación y extintores Special tools used during the comercial service and extinguishers	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	-	-
1.1.71	Remaining equipment bought by CAF: - Braking equipment: compressed air, vacuum, hydro mechanical, electro magnetically charged vacuum, disc brakes, etc. - Pneumatic equipment: for doors, pantograph risers, sanders, horns, rear view mirrors, wind screen wipers. - Air conditioning equipment Auxiliary equipment: vacuum WC, etc.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.72	Burletes de goma y fuelles de intercirculación Rubber gaskets and gangway bellows.	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	Según exigencias del plano According to requirements of the drawing	-
1.1.73	Materiales consumibles para procesos de soldadura: hilos, gases, fluxes. Consumables for welding processes: wires, gases, fluxes	Various	-	-	I	Acc.To P-11.03-BZ PCR	C/S	Acc.To P-11.03-BZ PCR	-	> Certificado s/ EN 10204-3.1/ Certificate s/IN 10204-3.1 > Ficha de Seguridad en primera entrega./ Material safety data sheet (MSDS) in the first delivery. > Marca CE s/ EN 13479/ Brand CE s/IN 13479	-
1.2	**MAIN PURCHASED EQUIPMENT INSPECTION AND TESTING PLAN -** *PLAN DE INSPECCIÓN Y ENSAYOS DE ELEMENTOS FUNDAMENTALES DE ACOPIO EXTERIOR*										
1.2.1	MAIN EQUIPMENT EQUIPOS PRINCIPALES		O	O	O						
1.2.1.1	PROPULSION SYSTEM SISTEMA DE TRACCIÓN	CAF Power& Automation	O	O	-	Q.41.92.101.02	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.101.02	Yes/Si
			-	-	O	Q.41.92.401.02	S/C	100%	-	Routine Test Certificate acc. Q.41.92.401.02	Yes/Si
1.2.1.2	BRAKE RESISTOR RESISTENCIA DE FRENO	CAF Power& Automation	O	O	-	Q.41.92.101.03	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.101.03	Yes/Si
			-	-	O	Q.41.92.401.03	S/C	100%	-	Routine Test Certificate acc. Q.41.92.401.03	Yes/Si
1.2.1.3	COMBINED TEST ENSAYO COMBINADO	CAF Power& Automation	O	-	-	Q.41.92.101.11	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.101.11	Yes/Si
1.2.1.4	PANTOGRAPH PANTÓGRAFO	SCHUNK	-	-	O	Q.41.92.402.00	S/T/C	1 Equipment	-	Routine Test Certificate acc. Q.41.92.402.00	Yes/Si
1.2.1.5	MASTER CONTROLLER	GESSMANN	O	O	-	Q.41.92.105.00	S/T/C	1 Equipment	H	Qualification Test Report acc.Q.41.92.105.00	Yes/Si

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1.2.1.5	MANIPULADOR DE TRACCIÓN	GEßMANN	-	-	O	Q.41.92.405.00	S/C	100%	-	Routine Test Certificate acc. Q.41.92.405.00	Yes/Si
1.2.1.6	AUXILIARY POWER SUPPLY/ LOW VOLTAGE POWER SUPPLY/BATTERY CHARGER APS/LVPS/CARGADOR DE BATERÍAS	CAF Power& Automation	O	O	-	Q.41.92.121.00 Q.41.92.421.00	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.121.00	Yes/Si
			-	-	O		S/C	100%	-	Routine Test Certificate acc. Q.41.92.421.00	Yes/Si
1.2.1.7	BATTERY BATERÍA	HOPPECKE	-	O	-	Q.41.92.422.00	S/C	1 Equipment	H	FAI Report	-
			-	-	O		S/C	100%	-	Routine Test Certificate acc. Q.41.92.422.00	Yes/Si
1.2.1.8	BRAKE SYSTEM SISTEMA DE FRENO	KBC	O	O	-	Q.41.92.132.00 Q.41.92.132.01	S/T/C	1 Equipment	H	Qualification Test Report acc.Q.41.92.132.00&.01	Yes/Si
			-	-	O	Q.41.92.432.00	S/C	100%	-	Routine Test Certificate acc. Q.41.92.432.00	Yes/Si
1.2.1.9	PASSENGER DOORS PUERTAS DE ACCESO VIAJEROS	IFE	O	O	-	Q.41.92.141.00	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.141.00	Yes/Si
1.2.1.10	HVAC AIRE ACONDICIONADO	MERAK	O	O	-	Q.41.92.151.00	S/T/C	1 Equipment	H	Qualification Test Report acc.Q.41.92.151.00	Yes/Si
			-	-	O	Q.41.92.451.00	S/C	100%	-	Routine Test Certificate acc. Q.41.92.451.00	Yes/Si
1.2.1.11	PIS-PAS-PA&CCTV SYSTEM SISTEMA PIS-PAS-PA&CCTV	SEPSA	O	O	-	Q.41.92.161.00	S/T/C	1 Equipment	H	Qualification Test Report acc.Q.41.92.161.00	Yes/Si
			-	-	O	Q.41.92.461.00	S/C	100%	R	Routine Test Certificate acc. Q.41.92.461.00	Yes/Si
1.2.1.12	EVENT RECORDER REGISTRADOR DE EVENTOS	HASLER	O	-	-	Q.41.92.163.00	S/T/C	1 Equipment	H	Qualification Test Report acc.Q.41.92.163.00	Yes/Si
			-	-	O	Q.41.92.463.00	S/C	100%	-	Routine Test Certificate acc. Q.41.92.463.00	Yes/Si
1.2.1.13	TCMS TCMS	CAF Power& Automation	-	-	O	Q.41.92.462.00	S/T/C	100%	-	Routine Test Certificate acc. Q.41.92.462.00	Yes/Si
1.2.1.14	GANGWAY PASILLO INTERCIRCULACIÓN	HÜBNER	O	O	-	Q.41.92.186.00	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.186.00	Yes/Si
1.2.1.15	GEARBOX REDUCTORA	CAF BEASAIN	O	O	-	M.H1.92.001.00	S/T/C	1 Equipment	H	Qualification Test Report acc. M.H1.92.001.00	Yes/Si
			-	-	O	M.H1.92.002.00	S/C	100%	-	Routine Test Certificate acc. M.H1.92.002.00	Yes/Si
1.2.1.16	LEVELING ACTUATOR ACTUADOR DE NIVELACIÓN	LIEBHERR	O	I	-	M.H1.92.006.00	S/T/C	1 Equipment	H	Qualification Test Report acc. M.H1.92.006.00	Yes/Si
1.2.1.17	TRACTION MOTOR MOTOR DE TRACCIÓN	CAF Power& Automation	O	O	-	Q.40.92.142.00	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.142.00	Yes/Si
			-	-	O	Q.41.92.401.01	S/C	100%	-	Routine Test Certificate acc. Q.41.92.401.01	Yes/Si
1.2.1.18	HEATERS CONVECTORES	CCI Thermal Technologies	O	O	-	Q.41.92.151.01	S/T/C	1 Equipment	H	Qualification Test Report acc. Q.41.92.151.01	Yes/Si
			-	-	O	Q.41.92.451.01	S/C	100%	-	Routine Test Certificate acc. Q.41.92.451.01	Yes/Si
1.2.2	OTROS OTHERS		O								
1.2.2.1	CARBODY STRUCTURAL TEST ENSAYO ESTRUCTURAL DE CAJA	CETEST	O	-	-	Q.41.92.010.00	C/T	1-Unit	H	Qualification Test Report acc. Q.41.92.010.00	Yes/Si
1.2.2.2	TRUCK STATIC AND FATIGUE TEST ENSAYO ESTÁTICO Y DE FATIGA DE BOGIE	CETEST	O	-	-	M.H1.92.010.00	C/T	1-Unit	H	Qualification Test Report acc. M.H1.92.010.00	Yes/Si
1.2.2.3	FLOOR ASSEMBLY FIRE TEST ENSAYO DE FUEGO MONTAJE SUELO	CETEST	O	-	-	Q.41.92.101.00	C/T	1-Unit	H	Qualification Test Report acc. Q.41.92.101.00	Yes/Si
1.2.2.4	ROOF ASSEMBLY FIRE TEST ENSAYO DE FUEGO MONTAJE TECHO	CETEST	O	-	-	Q.41.92.102.00	C/T	1-Unit	H	Qualification Test Report acc. Q.41.92.102.00	Yes/Si
1.3	**INSPECTION PLAN FOR THE REST OF PURCHASED MATERIALS** *PLAN DE INSPECCIÓN Y ENSAYOS PARA RESTO DE COMPONENTES DEL VEHÍCULO*			O/I							

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

INSPECTION AND TESTING PLAN

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1.3.1	Front and Side Cab Glasses *Lunas de Cabina frontal y laterales*	AGC GLASS EUROPE SA	-	O	-	Q.41.94.003 Q.41.94.017	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.2	Complete Cab Box (including fairings) Célula Completa (incluyendo carenados)	REFISA S.L.	-	O	-	Q.41.94.007	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.3	Door pillars Montantes poliester	MUNDIFIBRA, S.L.	-	O	-	Q.41.94.007	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.4	Desk Pupitre	MUNDIFIBRA, S.L.	-	O	-	Q.41.94.007	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.5	Lighting Luminaria	TEKNOWARE	-	O/I	-	Q.41.94.016	C/T/S	1st Unit	W	Test report Informe Pruebas	-
1.3.6	Articulation Articulación	LARGUI, S.L.	-	O/I	-	Q.41.42.031 Q.41.42.041	C/T/S	1st Unit	W	Test report Informe Pruebas	-
1.3.7	Saloon windows *Ventanas de Sala*	ORAN SAFETY GLASS	-	O/I	-	Q.41.94.004	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.8	Passenger seats Asientos de Pasajeros	SUNVIAUTO USA	-	O/I	-	Q.41.94.010	C/T/S	1st Unit	W	Test report Informe Pruebas	-
1.3.9	Driver´s Seat Asiento conductor	USSC LLC	-	O/I	-	Q.41.94.002	C/T/S	1st Unit	W	Test report Informe Pruebas	-
1.3.10	Floor panels Tableros	EKIDE, S.L.	-	I	-	Q.41.94.005	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.11	Floor covering Pavimento	NORA SYSTEMS	-	O/I	-	Q.41.94.006	C/T/S	1st Unit	-	Test report Informe Pruebas	-
1.3.12	HPL Interior linings Revestimientos interiores HPL	Composite Panel Solutions	-	O/I	-	Q.41.94.013	C/T/S	1st Unit	W	Test report Informe Pruebas	-
2	**BODYSHELLS MANUFACTURING AND TESTING PLAN -** *PLAN DE INSPECCION Y ENSAYOS EN FABRICACION DE CAJA*										
2.1	**GENERAL PROCESSES** *PROCESOS GENERALES*	CAF	I	-	I	-	-	-	-	-	-
2.1.1	Preparation of iron, steel and aluminium materials, previous to the manufacturing (Metal sheet work: cutting, laser cutting, plasma cutting, straightening, sanding, grinding, machining, folding etc.) Preparación de material siderúrgico previa a la fabricación (Calderería: corte, corte laser, corte por plasma, enderezado, lijado, esmerilado, mecanizado, plegado, etc)	-	-	-	-	P-10.08-BZ	-	-	-	-	-
2.1.1.01	Controls on product *Controles al producto*	CAF	-	-	I	N-10.08-BZ-01	F	Acc. to P-10.08-BZ	-	Acc. to the specified procedures and standards *Establecidos en procedimiento y normas especificadas*	-
2.1.1.02	Controls on process *Controles al proceso*	CAF	-	-	I	N-10.08-B-01	F	Acc. to P-10.08-BZ	-	Acc. to the specified procedures and standards *Establecidos en procedimiento y normas especificadas*	-
2.1.2	Manufacturing Process Controls established by the Manufacturing Engineering *Controles de Fabricación establecidos por Ingeniería de Producción (IP)*	CAF	-	-	I	Control&Instruction Sheets / *Fichas de Control&Instrucción*	F	100%	-	Control&Instruction Sheets / *Fichas de Control&Instrucción*	-

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2.1.3	General Welding Processes *Procesos Generales de Soldadura*	-	-	-	-	-	-	-	-	-	-
2.1.3.01	Control of Welding processes *Control de los Procesos de Soldadura*	CAF	-	-	I	AWS D17.2 AWS D1.1 AWS D1.6	F/C	100%	-	acc. to AWS D17.2, AWS D1.1, AWS D1.6	-
2.1.3.02	Qualified welding processes *Procesos de soldeo cualificados*	CAF	-	-	I	AWS D1.1 Clause 4 AWS D1.6 Clause 4	C	100%	-	Procedure Qualification Record (PQR)	-
2.1.3.03	Welding consumables *Consumibles de soldadura*	CAF	-	-	I	AWS A5.28 AWS A5.9	C	Acc. to N-11.03-BZ-01 *Según N-11.03-BZ-01*	-	Suppliers Certification *Certificados del proveedor*	-
2.1.3.04	Qualified welders *Soldadores cualificados*	CAF	-	-	I	AWS D1.1 Clause 4 AWS D1.6 Clause 4	F	-	-	Mod. RSC (Relación de soldadores cualificados) List of qualified welders	-
2.1.3.05	Preparation of joints to be welded *Preparación de juntas a soldar (chaflanes, separaciones)*	CAF	-	-	I	Planos Drawings	F	100%	-	-	-
2.1.3.06	Assembly and tack welding operations *Operaciones de armado y punteado*	CAF	-	-	I	Welding Procedure Specification (WPS)	F	100%	-	-	-
2.1.3.07	Assembly and tack welding operations *Operación de soldar*	CAF	-	-	I	Welding Procedure Specification (WPS)	F	100%	-	-	-
2.1.3.08	Visual inspection of welded joints *Inspeccion visual de las uniones soldadas*	CAF	-	-	I	AWS D17.2 (4.7.1) AWS D1.1 (6.1)	F	100%	-	-	-
2.1.3.09	NDT defined for this project: Magnetic Particle Inspection (M.T.) *END definidos para esta obra: Inspeccion por Particulas Magneticas (M.T.)*	CAF	-	-	I	AWS D1.1 (6.10)	C	100%	-	-	-
2.1.3.10	NDT defined for this project: Ultrasound Inspection (U.T.) *END definidos para esta obra: Inspeccion por Ultrasonidos (U.T.)*	CAF	-	-	I	AWS D1.1 (6.13) AWS D1.6 (6.13)	C	100%	-	-	-
2.1.3.11	NDT defined for this project: Penetrant Testing (P.T.) *END definidos para esta obra: Inspeccion por Líquidos Penetrantes (P.T.)*	CAF	-	-	I	AWS D1.1 (6.10)	C	100%	-	-	-
2.1.4	General Painting Processes *Procesos Generales de Pintura*	-	-	-	-	-	-	-	-	-	-
2.1.4.01	Certification of paint personnel *Homologación del personal de pintura*	CAF	-	-	I	N-10.03-BZ-02	F	100%	-	Acc. to standard *S/Norma*	-
2.1.4.02	Certification of painting processes *Homologación de procesos de pintura*	CAF	I	-	-	P-10.03-BZ N-10.03-BZ-01	F/C	Type	-	Acc. to standard *S/Norma*	-
2.1.4.03	Control of painting processes parts *Control de pintura de piezas y subconjuntos*	CAF	I	-	-	N-10.03-BZ-03	F	100%	-	Acc. to standard *S/Norma*	-
2.1.5	General processes: Wiring and Terminal Torque Tightening *Procesos Generales de Cableado y Apriete de Terminales*	-	-	-	-	-	-	-	-	-	-
2.1.5.01	Wiring Processes *Procesos de cableado*	CAF	-	-	I	N-10.11-BZ-04	F	Acc. to standard *S/Norma*	-	Acc. to standard *S/Norma*	-

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

PROJECT / PROYECTO : Cincinnati Streetcar

ANNEX 7 - Q.41.96.902

Issue/ Edición:	Project code/ Clave de obra
F	2317

city of CINCINNATI OFFICE OF THE CITY MANAGER

Item Item	Designation Denominación	Supplier Suministrador	Control Type: Qualif. Tipo	Control Type: FAI FAI	Control Type: Accept. Serie	Control Specification Especificación de Control	Responsible Responsable	Frequency Frecuencia	Customer Presence Presencia cliente	Records: Document Documento	Records: Customer delivery Entrega a cliente
2.1.5.02	Approval of wiring and terminal Tightening personnel *Homologación del personal de crimpado*	CAF	-	-	I	N-10.17-BZ-01	F	100%	-	Acc. to standard *S/Norma*	-
2.1.5.03	Terminal tightening processes *Procesos de apriete de terminales*	CAF	-	-	I	N-10.11-BZ-03	F	Acc. to standard *S/Norma*	-	Acc. to standard *S/Norma*	-
2.1.6	General Piping and Connector Processes *Procesos Generales de Tuberias y Racores*	-	-	-	-	-	-	-	-	-	-
2.1.6.01	Pipe manufacturing process *Procesos de fabricación de tubería*	CAF	-	-	I	P.10.12-B	F	Acc. to standard *S/Norma*	-	Acc. to standard *S/Norma*	-
2.1.6.02	Instructions for torque tightening of hose connectors (pneumatic and hydraulic) *Instrucciones de aplicación de pares de apriete en uniones de tubería (neumática e hidrúlica)*	CAF	-	-	I	W.00.00096	F	Acc. to standard *S/Norma*	-	Acc. to standard *S/Norma*	-
2.1.7	General Adhesion Processes *Procesos Generales de Adhesión*	-	-	-	-	-	-	-	-	-	-
2.1.7.01	Approval of bonders *Homologación del personal de adhesión*	CAF	-	-	I	N-10.16-BZ-03	F	100%	-	Acc. to standard *S/Norma*	-
2.1.7.02	Approval of adhesion processes *Homologación de procesos de adhesión*	CAF	I	-	-	P-10.16-BZ N-10.16-BZ-01	T/C	Tipo	-	Acc. to standard *S/Norma*	-
2.2	**TEST AND INSPECTION PLAN CARBODYSHELL STRUCTURE MANUFACTURING** *INSPECCION Y ENSAYOS EN FABRICACION DE LA CAJA*	CAF		I	I						
2.2.1	Cab Underframe Assembly C Cars *Montaje cabecero delantero Coches C*	CAF-Zaragoza	-	-	I	N-10.05-BZ-01	F	100%	-	Control Sheet / *F.Control* *Q.41.FC.A025.01*	-
2.2.2	Welding inspection: Cab headstock C Cars *Inspección soldadura de cabecero delantero Coches C*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.018*	Yes *Si*
2.2.3	Dimensional control: Cab headstock C Cars *Inspección dimensional de cabecero delantero coches C*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.009*	Yes *Si*
2.2.4	Underframe assembly C/S cars *Bastidor de coches C/S: Montaje*	CAF-Zaragoza	-	-	I	N-10.05-BZ-01	F	100%	-	Control Sheet / *F.Control* *Q.41.FC.A025.02* *Q.41.FC.A025.03*	-
2.2.5	Carshell body Underframe traceability of Casting pieces. *Trazabilidad piezas fundición bastidor de Caja*	CAF-Zaragoza	-	-	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* *Q.41.90.103*	Yes *Si*
2.2.6	Dimensional control of Articulation Bolster C/S Cars *Inspección dimensional de Traviesa de Articulación Coches C/S*	CAF-Zaragoza	-	-	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* *Q.41.90.001/* *Q.41.90.002*	Yes *Si*

INSPECTION AND TESTING PLAN
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PROJECT / PROYECTO : Cincinnati Streetcar

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

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ANNEX 7 - Q.41.96.902	
Issue/ Edición:	Project code/ Clave de obra
F	2317

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2.2.7	Welding control of Articulation Bolster C/S Cars *Inspección soldadura de Traviesa de Articulación Coches C/S*	CAF-Zaragoza	-	-	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* *Q.41.90.010/* *Q.41.90.011*	Yes *Si*
2.2.8	Welding inspection: Underframe C/S Cars *Inspección de soldaduras de bastidor de caja Coches C/S*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.012/* *Q.41.90.013*	Yes *Si*
2.2.9	Dimensional control: Underframe C/S Cars *Inspección dimensional de bastidor de caja Coches C/S*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.003/* *Q.41.90.004*	Yes *Si*
2.2.10	Roof assembly *Montaje de cubierta*	CAF-Zaragoza	-	-	I	N-10.05-BZ-01	F	100%	-	Control Sheet / *F.Control* Q.41.FC.A028.02 Q.41.FC.A028.03	-
2.2.11	Dimensional control: Roof C/S Cars *Inspección dimensional de cubierta Coches C/S*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.005/* *Q.41.90.006*	Yes *Si*
2.2.12	Welding inspection: Roof C/R/S Cars *Inspección de soldaduras de cubierta Coches C/R/S*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.014/* *Q.41.90.015*	Yes *Si*
2.2.13	Bodyside assembly *Costado: Montaje*	CAF-Zaragoza	-	-	I	N-10.05-BZ-01	F	100%	-	Control Sheet / *F.Control* Q.41.FC.A027.01	-
2.2.14	Carbody Assembly: *Armado de caja*	CAF-Zaragoza	-	-	I	N-10.05-BZ-01	F	100%	-	Control Sheet / *F.Control* Q.41.FC.A030.01	-
2.2.15	Global control: Carbody - C/S Cars *Control general de caja - Coches C/S*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.016/* *Q.41.90.017*	Yes *Si*
2.2.16	Dimensional control: Carbody C/S Cars *Inspección dimensional de caja Coches C/S*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.007/* *Q.41.90.008*	Yes *Si*
2.2.17	Carbody: Control of riveting process *Control proceso remachado en caja.*	CAF-Zaragoza	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* *Q.41.90.016/* *Q.41.90.017*	Yes *Si*
2.2.18	Carbody C/S (dimensional): Control in USA *Control Caja (dimensional) C/S en USA*	CAF-Elmira	-	I	I	Control Record *Planilla*	C/F	100%	W	Control Record *Planilla* *Q.41.90.020/* *Q.41.90.021*	Yes *Si*

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2.2.19	Carbody Assembly in Elmira: *Armado de caja en Elmira*	CAF-Elmira	-	-	I	N-10.05-BZ-01	F	100%	-	Control Sheet / F.Control Q.41.FC.B027.01	-
2.3	**BODYSHELL FINISHING. PAINTING PROCESS** *FABRICACION Y ACABADO DE CAJA. PROCESO DE PINTURA.*	CAF		I	I						
2.3.1	Carbodyshell painting process control *Control del proceso de pintado de caja*	CAF-Zaragoza	-	-	I	Control Sheets *Ficha Control*	F	100%	-	Control Sheets / F.Control Q.41.FC.B058.01 / .02 / .03	-
2.3.2	Control of Carbodyshell painted *Control de caja pintada*	CAF-Zaragoza	-	I	I	Acc.Drawing and Tech.Specification *Según planos y Especificación Técnica*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* Q.41.90.050	Yes *Si*
2.4	**BODYSHELL FINISHING AND ASSEMBLY** *FABRICACION Y ACABADO DE CAJA*	CAF		I	I						
2.4.1	**General Processes** *Procesos generales*										
2.4.2	**Car finishing. Stage P1** *Montajes de acabado. Posición P1*				I						
2.4.2.1	Manufacturing of grounds *Fabricación P.A.T*	CAF-Elmira	-	-	I	P-10.02-BZ	F	100%	-	-	-
2.4.2.2	Preparar Cableado *Prepare Wiring*	CAF-Elmira	-	-	I	P-10.02-BZ	F	100%	-	-	-
2.4.2.3	Connections checking Electrical workshop *Control de conexionados Taller eléctrico*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet&Data / Ficha&Gama Control Q.41.FC.B077.10 / 11 / 12	-
2.4.2.4	Electrical conduits preassembly *Premontaje conductos eléctricos*	CAF-Elmira	-	-	I	Instruction Sheet / *Ficha Instrucción*	F	100%	-	Instruction Sheet / Ficha Instrucción Q.41.FI.B084.01	-
2.4.2.5	Control mounted subassemblies in electrical workshop (equiped driver desk + cabin cabinets + department panels + battery box) *Control de subconjuntos montados en Taller eléctrico (pupitres equipados + armarios de cabina + paneles departamento + cofre de batería)*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Part	Inspection Sheet / Ficha Inspección F 14-02-EL-01	-
2.4.3	**Car finishing. Stage P3** *Montajes de acabado. Posición P3*				I						
2.4.3.1	Interior roof insulation fitment *Montaje de aislamientos en interior de cubierta*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	F	100%	-	-	-
2.4.3.2	Internal roof assemblies stage 1 *Montajes en interior cubierta fase 1*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / Ficha Control&Instrucción Q.41.FC.B048.01 Q.41.FI.B048.01	-
2.4.3.3	Connections checking *Control de conexionados*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / Ficha Control Q.41.FC.B077.00 / 01 / 02	-
2.4.3.4	External roof assemblies stage 1 *Montajes en exterior cubierta fase 1*	CAF-Elmira	-	-	I	Control Sheet / *Ficha Control*	F	100%	-	Control Sheet / F.Control Q.41.FC.B073.01	-
2.4.3.5	Roof internal wiring inspection *Inspección cableado interior en cubierta*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / Ficha Inspección F 14-02-EL-01	-

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2.4.3.6	Internal roof assemblies stage 2 *Montajes en interior cubierta fase 2*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B048.02 Q.41.FI.B048.02	-
2.4.3.7	Electrical conduits preassembly *Premontaje conductos eléctricos*	CAF-Elmira	-	-	I	Instruction Sheet / *Ficha Instrucción*	F	100%	-	Instruction Sheet / *Ficha Instrucción* Q.41.FI.B084.01	-
2.4.3.8	Roof inspection prior to assembly *Inspección cubierta previa a su montaje*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.4	**Car finishing. Stage P4** *Montajes de acabado. Posición P4*				I						
2.4.4.1	Hydraulic and pneumatic pipes assembly *Montaje de tubería hidraúlica y pneumática*	CAF-Elmira	-	-	I	Instruction Sheet / *Ficha Instrucción*	F	100%	-	Instruction Sheet / *Ficha Instrucción* Q.41.FI.B022.01	-
2.4.4.2	Cabin conduits assembly & Electrical conduits preassembly *Montaje de conductos de cabina&Premontaje conductos eléctricos*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Instruction Sheet / *Ficha Instrucción* Q.41.FC.B084.01 Q.41.FI.B084.01	-
2.4.4.3	Eq. Cabin conduits *Equip. de conductos de cabina*	CAF-Elmira	-	-	I	Control Sheet / *Ficha Control*	F	100%	-	Instruction Sheet / *Ficha Instrucción* Q.41.FC.B084.02	-
2.4.4.4	Headstock installation + Cab Pneumatic piping assbly *Equipar cabecero + Montaje tubería neumática Cabina*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B025.01	-
2.4.4.5	Cab windows assembly *Montaje lunas de cabina*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B040.01 Q.41.FI.B040.01	-
2.4.4.6	Cab floor & Cabinets assembly *Montaje de armarios y pavimento en cabina*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B087.01 Q.41.FI.B087.01	-
2.4.4.7	Cab floor assembly *Montaje de pavimento en cabina*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.4.8	Connections checking *Control de conexionados*	CAF-Elmira	-	-	I	Control Sheet&Data *Ficha&Gama Control*	F	100%	-	Control Sheet&Data / *Ficha&Gama Control* Q.41.FC.B077.00 / 01 / 02	-
2.4.4.9	Equipped headstock inspection (before assbly in Carshell) *Insp. cabecero equipado (antes de montar a Caja)*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	C	100%	H-1st.Part	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.6	**Car finishing. Stage Z1** *Montajes de acabado. Posición Z1*				I						
2.4.6.1	Integration Car Phase1 (Carbody Assembly out of roof) *Integración de coche Fase1(Armar Caja excepto cubierta)*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B030.01 Q.41.FI.B030.01	-
2.4.6.2	Insulation preassembly *Premontaje de aislamientos*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B045.01	-
2.4.6.3	Insulation assembly *Montaje de aislamientos*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B045.02	-

Item / Item	Designation / Denominación	Supplier / Suministrador	Control Type: Qualif. / Tipo	Control Type: FAI / FAI	Control Type: Accept. / Serie	Control Specification / Especificación de Control	Responsible / Responsable	Frequency / Frecuencia	Customer Presence / Presencia cliente	Records: Document / Documento	Records: Customer delivery / Entrega a cliente
2.4.6.4	Insulation + Floorpanels assembly *Montaje de tableros y aislamiento de piso*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B046.01	-
2.4.6.5	Floor inspection (before floorpanels fitment) *Inspección piso (antes montar tableros)*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	1st.Unit	H-1st.Unit	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.6.6	Floor panels assembly inspection *Inspección montaje tableros piso*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	1st.Unit	H-1st.Unit	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.6.7	Rubber floor covering assembly *Montaje pavimento*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B046.02 Q.41.FI.B046.02	-
2.4.6.8	Floor pavement fitment inspection - Z1 *Inspección Montaje pavimento - Z1*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.6.9	Footstep assembly *Montaje de peldaño*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B035.03	-
2.4.6.10	Dual Lock assembly *Montaje de Dual Locks*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B048.03 Q.41.FI.B048.03	-
2.4.6.11	Poliester Parts assembly *Montaje de piezas de Poliéster*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B048.05	-
2.4.6.12	Heaters+Convectors assembly *Montaje de calefactores y convectores*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B082.01	-
2.4.6.13	Windows assembly *Montaje de ventanas*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B040.02	-
2.4.6.14	Window assembly inspection *Inspección montaje ventanas*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.7	**Car finishing. Stage Z2** *Montajes de acabado. Posición Z2*				I						
2.4.7.1	Integration Car Phase2 (Roof Assembly) *Integración de coche Fase2 (Armar cubierta)*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B030.02 Q.41.FI.B030.02	-
2.4.7.2	Headstock, cabin and coupler assembly *Montaje de testero, cabina y enganche*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B033.01	-
2.4.7.3	Car fairings + Light assembly *Montaje de carenados y faros*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B033.02	-
2.4.7.4	Car integration inspection (roof permanently rivetted) *Inspección caja armada (techo fijado permanentemente)*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.7.5	In line watertightness local test *Prueba estanqueidad en Línea*	CAF-Elmira	-	-	I	Acc.Procedure *Según protocolo*	C	100%	H	Control record / *Planilla* Q.41.90.100	-
2.4.7.6	Bellow and lower articulation assembly *Montaje de intercomunicación y Rótula*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B042.01 Q.41.FI.B042.01	-
2.4.7.7	Half articulation assembly inspection *Inspección montaje media articulación*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	1st.Unit	H-1st.Unit	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-

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2.4.7.8	Fire sealing *Sellado fuego*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B045.03	-
2.4.7.9	Underframe equipment (Uf.pneum+Hyd+Elec) assembly *Montaje aparatos B/B (pneumát+hid+elec)*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B022.01	-
2.4.7.10	Underframe piping (electrical, pneumatic & hidraulic) *Montaje tubería B/B (eléctrica, neumática e hidráulica)*	CAF-Elmira	-	-	I	Instruction Sheet *Ficha Instrucción*	F	100%	-	Instruction Sheet / *Ficha Instrucción* Q.41.FI.B022.01	-
2.4.7.11	Door leaves assembly *Montaje puertas*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B035.01	-
2.4.7.12	Side covers assembly *Montaje de carenados laterales*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B048.06	-
2.4.7.13	Side trapdoors assembly *Montaje de trampillas laterales*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B048.07	-
2.4.7.14	Interior equipment and passenger handrails assbly. *Montaje aparatos interior de sala y asideros*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B074.01	-
2.4.7.15	Cab interiorism & partition lining assembly *Montaje interiorismo y revestimientos tabique*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B049.01	-
2.4.7.16	Connections checking *Control de conexionados*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet&Data / *Ficha&Gama Control* Q.41.FC.B077.00 / 01 / 02	-
2.4.7.17	Underframe finishing inspection *Inspección acabados bajo bastidor*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.8	**Car finishing. Stage Z3** *Montajes de acabado. Posición Z3*				I						
2.4.8.1	Pneumatic & hidraulic pipes assembly *Montaje tubería neumática e hidráulica*	CAF-Elmira	-	-	I	Instruction Sheet *Ficha Instrucción*	F	100%	-	Instruction Sheet / *Ficha Instrucción* Q.41.FI.B022.01	-
2.4.8.2	Underframe insulation assembly *Montaje aislamiento bajo bastidor*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B045.04	-
2.4.8.3	Passenger Access doors Adjustment *Regulación puertas de Acceso Viajeros*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B035.02	-
2.4.8.4	Roof fairing assembly *Montaje carenado superior*	CAF-Elmira	-	-	I	Control&Instruction Sheet */ Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B031.01 Q.41.FI.B031.01	-
2.4.8.5	Side fairing and bogie skirts assembly *Montaje carenados laterales y faldones*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B031.02	-
2.4.8.6	Car fairings + Light assembly *Montaje carenados y faros*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B033.02	-
2.4.8.7	Exterior finishing inspection *Inspección acabados exterior*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.8.8	Upper articulation and damper assembly *Montaje articulación superior y amortiguador*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B042.02	-
2.4.8.9	Roof elec. equipment assembly *Montaje aparatos elect. en cubierta*	CAF-Elmira	-	-	I	Control&Instruction Sheet */ Ficha Control&Instrucción*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B073.02	-
2.4.8.10	Roof inspection *Inspección en cubierta*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

PROJECT / *PROYECTO* **: Cincinnati Streetcar**

ANNEX 7 - Q.41.96.902

Issue/ *Edición:*	Project code/ *Clave de obra*
F	2317

city of CINCINNATI OFFICE OF THE CITY MANAGER

Item *Item*	Designation *Denominación*	Supplier *Suministrador*	Control Type: Qualif. *Tipo*	Control Type: FAI *FAI*	Control Type: Accept. *Serie*	Control Specification *Especificación de Control*	Responsible *Responsable*	Frequency *Frecuencia*	Customer Presence *Presencia cliente*	Records: Document *Documento*	Records: Customer delivery *Entrega a cliente*
2.4.8.11	Saloon seats assembly *Montaje asientos de sala*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B052.01	-
2.4.8.12	Connections checking *Control de conexionados*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B077.00 / 01 / 02	-
2.4.8.13	Interior finishing inspection *Inspección acabados interior*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.9	**Car finishing. Stage Z3+ or Z0** *Montajes de acabado. Posición Z3+ o Z0*			I	I						
2.4.9.1	Get down car onto Trucks+Fixing+ Pneumat.Connec. *Bajar coche a bogie+Amarrar+Conex.neumat.*	CAF-Elmira	-	-	I	Control&Instruction Sheet / *Ficha Control&Instrucción*	F	100%	-	Control&Instruction Sheet / *Ficha Control&Instrucción* Q.41.FC.B026.01 Q.41.FI.B026.01	-
2.4.9.2	Get down car onto Trucks+Fixing+ Pneumat.Connec. *Bajar coche a bogie+Amarrar+Conex.neumat.*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H-1st.Unit W-Rest of units	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.9.3	Lower and Upper Articulation assembly inspection *Inspección montaje articulación superior e inferior*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	H	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.9.4	Rotatory platform assembly *Montaje plato giratorio*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B042.03	-
2.4.9.5	Obstacle deflector System assembly *Montaje Antiatrapapersonas*	CAF-Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	Control Sheet / *Ficha Control* Q.41.FC.B023.01	-
2.4.9.6	Finishing inspection complete Unit before testing *Inspección acabados Unidad completa antes pruebas*	CAF-Elmira	-	-	I	Acc.Drawing *Según plano*	C	100%	-	Inspection Sheet / *Ficha Inspección* F 14-02-EL-01	-
2.4.9.7	Main serial numbered Subsystems Números de Serie elementos principales	CAF-Elmira	-	-	I	Control Record *Planilla*	F/C	100%	R	Control Record / *Planilla* Q.41.90.500	Yes Si
2.4.9.8	Final finishing inspection complete Unit *Inspección final de acabados Unidad completa*	CAF-Elmira	-	I	I	Control Record *Planilla*	C	100%	H	Control Record / *Planilla* Q.41.90.122	Yes Si
2.4.9.9	Pre-Shipping Inspection *Inspección previa entrega*	CAF-Elmira	-	-	I	Control Record *Planilla*	F/C	100%	H	Control Record / *Planilla* Q.41.90.120	Yes Si
2.4.9.10	Post-Shipping Inspection (in Cincinnati) *Inspección tras entrega (en Cincinnati)*	CAF-Elmira	-	-	I	Control Record *Planilla*	F/C	100%	H	Control Record / *Planilla* Q.41.90.121	Yes Si
2.4.9.11	Final finishing inspection complete Unit after On Track testing (in Cincinnati) *Inspección final de acabados Unidad completa tras Pruebas Vía (en Cincinnati)*	CAF-Elmira	-	-	I	Control Record *Planilla*	C	100%	H	Control Record / *Planilla* Q.41.90.122	Yes Si
3	**TRUCKS MANUFACTURING AND TESTING PLAN -** *PLAN DE INSPECCION Y ENSAYOS EN FABRICACION DE BOGIE*										
3.1	**TRUCK STRUCTURE MANUFACTURING** *FABRICACION DE ESTRUCTURA DE BOGIE*	CAF		I	I						
3.1.1	Assembly and welding: Truck frame *Armar y soldar Bastidor de Bogie*	CAF Beasain	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B250700*	-
3.1.2	Brackets and console mounting *Montaje de soportes y consola*	CAF Beasain	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B250800*	-
3.1.3	NDT: Truck frame welds *Verificación por END de soldaduras de Bastidor de Bogie*	CAF Beasain	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* M.H1.90.112	Yes *Si*

	INSPECTION AND TESTING PLAN *PLAN DE INSPECCIÓN Y ENSAYOS* CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A. **PROJECT** / *PROYECTO* : **Cincinnati Streetcar**							ANNEX 7 - Q.41.96.902 Issue/ *Edición:* F	Project code/ *Clave de obra* 2317	city of CINCINNATI OFFICE OF THE CITY MANAGER	
			Control Type							Records	
Item *Item*	**Designation** Denominación	**Supplier** *Suministrador*	**Qualif.** *Tipo*	**FAI** *FAI*	**Accept.** *Serie*	**Control Specification** *Especificación de Control*	**Responsible** *Responsable*	**Frequency** *Frecuencia*	**Customer Presence** *Presencia cliente*	**Document** *Documento*	**Customer delivery** *Entrega a cliente*
3.1.4	Bogie frame traceability of Casting pieces. Trazabilidad piezas fundición bastidor de Bogie	CAF Beasain	-	-	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* M.H1.90.101	Yes *Si*
3.1.5	Heat treatment verification: Truck frame *Verificación del tratamiento térmico de bastidor de bogie*	CAF Beasain	-	I	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* M.H1.90.102	Yes *Si*
3.1.6	Machining of Truck frame *Mecanizar Bastidor de Bogie*	CAF Beasain	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B250900*	-
3.1.7	Dimensional control: Machined Truck frame *Verificación dimensional de Bastidor de Bogie mecanizado*	CAF Beasain	-	I	I	Control Record *Planilla*	C/F	100%	W - FAI R - Rest of units	Control Record *Planilla* M.H1.90.103	Yes *Si*
3.1.8	Painting of Truck frame *Pintar bastidor de bogie*	CAF Beasain	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B251000*	-
3.1.9	Painting inspection: Truck frame *Verificación de bastidor de bogie pintado*	CAF Beasain	-	I	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* M.H1.90.104	Yes *Si*
3.1.10	Dimensional control: Truck mounted bridge *Verificación dimensional de puente montado*	CAF Beasain	-	I	I	Control Record *Planilla*	C/F	100%	R	Control Record *Planilla* M.H1.90.105	Yes *Si*
3.2	**TRUCK FINISHING ASSEMBLY** *FABRICACIÓN ACABADO DE BOGIE*	CAF			I						
3.2.1	Primary suspension assembly *Montaje suspensión primaria*	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B050100*	-
3.2.2	Secondary suspension assembly *Montaje suspensión secundaria*	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B060100*	-
3.2.3	Engine assembly *Montaje del conjunto motorización*	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B110100*	-
3.2.4	Brake equipment assembly Montaje de equipamiento de freno	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B190100*	-
3.2.5	Electromagnetic brake assembly Montaje del freno electromagnetico	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B200100*	-
3.2.6	Inscriptions assembly Montaje inscripciones	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1B570100*	-
3.2.7	Equipment of gear unit - motor subassemblies Montaje subconjuntos motor-reductor	CAF Elmira	-	-	I	Control Sheet *Ficha Control*	F	100%	-	F.Control / *Control Sheet* *MH1A112001*	-
3.3	**TRUCKS FINAL TESTS** *PRUEBAS FINALES DE BOGIES*	CAF		I	I						
3.3.1	Serial numbers: Truck Parts *Identificación de Elementos bogie*	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	H-1st.Unit W-Rest of units	Control Record *Planilla* M.H1.90.106	Yes *Si*
3.3.2	Electric Resistance Verification *Verificación de Resistencia eléctrica*	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	W - 1st Truck R - Rest of units	Control Record *Planilla* M.H1.90.108	Yes *Si*
3.3.3	Electric Resistance Verification between wheels *Verificación de Resistencia eléctrica entre ruedas*	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	W - 1st Truck R - Rest of units	Control Record *Planilla* M.H1.90.113	Yes *Si*

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3.3.4	Truck running test *Ensayo de rodaje*	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	W - 1st Truck R - Rest of units	Control Record *Planilla* M.H1.90.111	Yes *Si*
3.3.5	Truck under press test *Verificación bajo prensa*	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	W - 1st Truck R - Rest of units	Control Record *Planilla* M.H1.90.109	Yes *Si*
3.3.6	Pneumatic tightness under secondary suspension Verificación estanqueidad neumática bajo secundaria	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	W - 1st Truck R - Rest of units	Control Record *Planilla* M.H1.90.107	Yes *Si*
3.3.7	Truck Dielectric Strength and Insulation Resistance *Rigidez y Aislamiento de bogie*	CAF Elmira	-	-	I	Control Record *Planilla*	C/F	100%	W - 1st Truck R - Rest of units	Control Record *Planilla* M.H1.90.114	Yes *Si*
3.3.8	Final inspection: Finished Truck *Verificaciones finales de acabado de bogie completo*	CAF Elmira	-	I	I	Control Record *Planilla*	C/F	100%	H-FAI R - Rest of units	Control Record *Planilla* M.H1.90.110	Yes *Si*
4	**FINAL INSPECTION AND TESTING PLAN: FACTORY TESTS AND ON TRACK TESTS -** *PLAN DE PRUEBAS Y ENSAYOS FINALES: PRUEBAS FACTORÍA Y PRUEBAS VÍA*										
4.1	**FACTORY QUALIFICATION TESTS** *ENSAYOS TIPO FACTORÍA*	CAF	I								
4.1.1	Batterycapacity	CAF Elmira	I	-	-	Q.41.92.222.00	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.2	Traincontrol and monitoring system	CAF Elmira (CAF P&A)	I	-	-	Q.41.92.233.00	F/S/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.3	HMI fault verification	CAF Elmira	I	-	-	Q.41.92.234.00	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.4	Electrical Auxiliaries	CAF Elmira	I	-	-	Q.41.92.235.01	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.5	Passenger doors system	CAF Elmira (IFE)	I	-	-	Q.41.92.241.00	F/S/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.6	Air balance	CAF Elmira	I	-	-	Q.41.92.251.01	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.7	Climatic room	CAF Elmira	I	-	-	Q.41.92.251.02	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.8	PISPASPA + CCTV system	CAF Elmira (SEPSA)	I	-	-	Q.41.92.261.00	F/S/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.9	Event recorder	CAF Elmira (HASLER)	I	-	-	Q.41.92.263.00	F/S/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.10	Souplesse and wheel off-load	CAF Elmira	I	-	-	Q.41.92.275.20	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.11	Grounding and return circuits	CAF Elmira	I	-	-	Q.41.92.276.02	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.12	Ducting watertightness	CAF Elmira	I	-	-	Q.41.92.276.04	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.13	Gauging	CAF Elmira	I	-	-	Q.41.92.277.02	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*

Item *Item*	Designation *Denominación*	Supplier *Suministrador*	Control Type: Qualif. *Tipo*	Control Type: FAI *FAI*	Control Type: Accept. *Serie*	Control Specification *Especificación de Control*	Responsible *Responsable*	Frequency *Frecuencia*	Customer Presence *Presencia cliente*	Records: Document *Documento*	Records: Customer delivery *Entrega a cliente*
4.1.14	Curve negotiation	CAF Elmira	I	-	-	Q.41.92.277.03	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.15	Lightintensity	CAF Elmira	I	-	-	Q.41.92.278.20	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.16	Air leakage	CAF Elmira	I	-	-	Q.41.92.278.30	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.1.17	Emergency coupler	CAF Elmira	I	-	-	Q.41.92.291.00	F/T/C	1-Unit	W	Test report *Informe Pruebas*	Yes *Si*
4.2	**FACTORY ACCEPTANCE TESTS** *ENSAYOS SERIE FACTORÍA*	CAF			I						
4.2.1	Propulsion system	CAF Elmira (CAF P&A)	-	-	I	Q.41.92.501.00	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.2	Software versions	CAF Elmira	-	-	I	Q.41.92.525.00	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.3	Brake and leveling system	CAF Elmira (KBC)	-	-	I	Q.41.92.532.00	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.4	Traincontrol and monitoring system	CAF Elmira (CAF P&A)	-	-	I	Q.41.92.233.00	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.5	Sand and lubrication system	CAF Elmira	-	-	I	Q.41.92.533.00	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.6	Electrical auxiliaries	CAF Elmira	-	-	I	Q.41.92.535.01	F/C	2nd.to5thUnit	W	Test report *Informe Pruebas*	Yes *Si*
4.2.7	Electrical auxiliaries -safety	CAF Elmira	-	-	I	Q.41.92.535.02	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.8	Electrical auxiliaries -driving	CAF Elmira	-	-	I	Q.41.92.535.03	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.9	Passenger doors system	CAF Elmira	-	-	I	Q.41.92.541.00	F/C	2nd.to5thUnit	W	Test report *Informe Pruebas*	Yes *Si*
4.2.10	HVAC	CAF Elmira	-	-	I	Q.41.92.551.00	F/C	2nd.to5thUnit	W	Test report *Informe Pruebas*	Yes *Si*
4.2.11	PISPASPA + CCTV system	CAF Elmira (SEPSA)	-	-	I	Q.41.92.561.00	F/C	2nd.to5thUnit	W	Test report *Informe Pruebas*	Yes *Si*
4.2.12	Event recorder	CAF Elmira (HASLER)	-	-	I	Q.41.92.563.00	F/C	2nd.to5thUnit	W	Test report *Informe Pruebas*	Yes *Si*
4.2.13	Insulation resistance and high potential	CAF Elmira	-	-	I	Q.41.92.572.00	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.14	Vehicle weight	CAF Elmira	-	-	I	Q.41.92.575.01	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.15	Grounding and return circuits	CAF Elmira	-	-	I	Q.41.92.576.02	F/C	2nd.to5thUnit	W	Test report *Informe Pruebas*	Yes *Si*
4.2.16	Vehicle watertightness	CAF Elmira	-	-	I	Q.41.92.576.04	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.17	Vehicle leveling	CAF Elmira	-	-	I	Q.41.92.577.01	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*
4.2.18	Overall dimensions	CAF Elmira	-	-	I	Q.41.92.578.01	F/C	100%	W	Test report *Informe Pruebas*	Yes *Si*

INSPECTION AND TESTING PLAN

PLAN DE INSPECCIÓN Y ENSAYOS

CONSTRUCCIONES Y AUXILIAR DE FERROCARRILES S.A.

PROJECT / PROYECTO : Cincinnati Streetcar

ANNEX 7 - Q.41.96.902	
Issue/ Edición:	Project code/ Clave de obra
F	2317

city of CINCINNATI OFFICE OF THE CITY MANAGER

Item / Item	Designation / Denominación	Supplier / Suministrador	Control Type: Qualif. / Tipo	Control Type: FAI / FAI	Control Type: Accept. / Serie	Control Specification / Especificación de Control	Responsible / Responsable	Frequency / Frecuencia	Customer Presence / Presencia cliente	Records: Document / Documento	Records: Customer delivery / Entrega a cliente
4.2.19	Exterior lighting	CAF Elmira	-	-	I	Q.41.92.578.20	F/C	2nd.to5thUnit	W	Test report / Informe Pruebas	Yes / Si
4.2.20	Obstacle deflector system	CAF Elmira	-	-	I	Q.41.92.594.00	F/C	100%	W	Test report / Informe Pruebas	Yes / Si
4.3	**ON-TRACK QUALIFICATION TESTS** / *ENSAYOS TIPO VÍA*										
4.3.1	Propulsion system	CAF Elmira	I/O*	-	-	Q.41.92.301.00	F/S/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.2	Thermal Capacity	CAF Elmira	I/O*	-	-	Q.41.92.323.00	F/S/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.3	Brake System	CAF Elmira	I/O*	-	-	Q.41.92.332.00	F/S/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.4	PISPASPA + CCTV System	CAF Elmira	I/O*	-	-	Q.41.92.361.00	F/S/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.5	EMC	CAF Elmira	I/O*	-	-	Q.41.92.375.10	F/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.6	Noise and Vibration	CAF Elmira	I/O*	-	-	Q.41.92.375.15	F/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.7	Ride quality and comfort	CAF Elmira	I/O*	-	-	Q.41.92.375.25	F/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.8	Lifting capability	CAF Elmira	I/O*	-	-	Q.41.92.377.40	F/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.3.9	Coupling capability	CAF Elmira	I/O*	-	-	Q.41.92.391.00	F/T/C	1-Unit	W	Test report / Informe Pruebas	Yes / Si
4.4	**ON-TRACK ACCEPTANCE TESTS** / *ENSAYOS SERIE VÍA*										
4.4.1	Event Recorder	CAF Elmira	-	-	I/O*	Q.41.92.663.00	F/C	100%	W	Test report / Informe Pruebas	Yes / Si
4.4.2	500 km operational test	CAF Elmira	-	-	I/O*	Q.41.92.679.01	F/C	100%	W	Test report / Informe Pruebas	Yes / Si
4.4.3	Propulsion system	CAF Elmira	-	-	I/O*	Q.41.92.301.00	F/C	100%	W	Test report / Informe Pruebas	Yes / Si
4.4.4	Brake System	CAF Elmira	-	-	I/O*	Q.41.92.332.00	F/C	100%	W	Test report / Informe Pruebas	Yes / Si
4.4.5	Post-delivery test	CAF Elmira	-	-	I/O*	Q.41.92.679.02	F/C	100%	W	Test report / Informe Pruebas	Yes / Si

GLOSSARY / GLOSARIO

Control type:
Tipo de Control:
O : Origin / *Origen*
I : Internal / *Interna*
I/O*: Details of location of the test at the official Project Schedule

Responsible
Responsable:
F : Manufacturing Dpt. / *Fabricación*
C : Quality Dpt. / *Calidad*
T : Engineering Dpt. / *O. Técnica*
S : Supplier / *Suministrador*

Customer Presence:
Presencia del cliente:
R : Records review / Revisión registros
W : Witness point / *Punto de Aviso*
H : Hold point / *Punto de Espera*

Appendix XX

Test Completion Dates

Main Equipment	Test Report	Letter	Date
PROPULSION SYSTEM	Traction Inverter Qualification Test Report	CINCAF 962	3-Jun-15
	AC Traction Motor Qualification Test Report	CINCAF 715	19-Dec-14
	AC Traction Motor FAI Report	CINCAF 1431	14-Apr-16
BRAKE RESISTOR	Brake Resistor Qualification Test Report	CINCAF 1136	27-Aug-15
	Brake Resistor FAI Report	CINCAF 678	25-Nov-14
COMBINED TEST	Propulsion System Qualification Test Report - Combined Test	CINCAF 1305	18-Dec-15
MASTER CONTROLLER	Master Controller Qualification Test Report	CINCAF 1053	22-Jul-15
	Master Controller FAI Report	CINCAF 1053	22-Jul-15
AUXILIARY POWER SUPPLY	Auxiliary Power Supply Qualification Test Report	CINCAF 1193	14-Oct-15
	Auxiliary Power Supply FAI Report	CINCAF 1150	14-Sep-15
LVPS/BATTERY CHARGER	LVPS and BC Qualification Test Report	CINCAF 1193	14-Oct-15
	LVPS and BC FAI Report	CINCAF 1150	14-Sep-15
BATTERY	Battery FAI Report	CINCAF 759	6-Feb-15
BRAKE SYSTEM	Friction Brake System Qualification Test Report	CINCAF 1016	18-Jun-15
	Friction Brake System FAI Report	CINCAF 1097	14-Aug-15
	EHU FAI Report	CINCAF 1196	20-Oct-15
PASSENGER DOORS	Door System Qualification Test Report	CINCAF 1439	14-Apr-16
	Door System FAI Report	CINCAF 1272	3-Dec-15
HVAC	Unitized HVAC System Qualification Test Report	CINCAF 1571	26-Aug-16
	Unitized HVAC System FAI Report	CINCAF 1453	26-Apr-16
PIS-PAS-PA&CCTV SYSTEM	PIS PAS PA & CCTV Qualification Test Report	CINCAF 1288	11-Dec-15
	PIS PAS PA & CCTV FAI Report	CINCAF 775	17-Feb-15
GANGWAY	Gangway Qualification Test Report	CINCAF 0699	12-Dec-14
	Gangway FAI Report	CINCAF 860	7-Apr-15
GEARBOX	Traction Gear Unit Qualification Test Report	CINCAF 0744	21-Jan-15
	Traction Gear Unit FAI Report	CINCAF 1292	18-Feb-16
LEVELING ACTUATOR	Leveling Qualification Test Report	CINCAF 1072	4-Aug-15
	Leveling FAI Report	CINCAF 1095	14-Aug-15

TABLE OF CONTENTS

Sub-Part C – MANAGEMENT APPROACH AND SCHEDULE

SECTION E CONCEPTUAL TEST PLAN

Included in Appendices CE.1 and CE.2 are a copy of the approved Inspection and Testing Plan, (Q.41.96.902) for the Cincinnati Streetcar project, and a spreadsheet identifying the approval letters and dates for the major system qualification tests and FAI respectively. For the Center City Connector Streetcar project, CAF will propose a similar Inspection and Testing Plan to that approved by Cincinnati with the addition of the OESS and with the exception of certain Qualification Tests and FAIs corresponding to systems that will also be supplied for this project and do not need to be repeated, (subject to SDOT's approval).

CAF will provide copies of these previously performed and approved inspections and tests for SDOT's information upon request.

CAF uses a proven methodology to systematically identify and address all of the testing requirements. A simplified outline follows:

- Create a matrix documenting all of the technical specification testing requirements and all CAF and sub-supplier testing requirements.
- Create a master Inspection and Testing Plan, listing all of the individual tests. The Plan is then submitted for approval by SDOT. Plan will be revised and resubmitted as needed.
- Create testing procedures for all of the individual tests listed in the Master Test Plan.
- Cross check the individual testing procedures against the testing requirements matrix to ensure that all testing requirements have been met. Revise as necessary.
- Submit the individual test procedures for approval by SDOT. Once the individual test procedures are approved, testing will be scheduled.
- Tests will be performed, witnessed as required, and test reports submitted for approval by SDOT.
- Upon approval by SDOT, the requirements matrix will be double checked to ensure that all requirements have been satisfactorily achieved.

Refer to Sub-Part C Sections D and F for further information about locations and available facilities where major tests will be performed.

SUPPLY OF 10 STREETCARS FOR THE CITY OF SEATTLE

- PROPOSER'S SCHEDULE -

Id	Task Name	Duration	Date
1	**MANUFACTURING AND DELIVERY OF VEHICLES FOR SEATTLE**	856 d	
2	**GENERAL**	856 d	
3	NTP	0 d	01/09
4	**KEY ACTIONS AND DELIVERABLES**	796 d	
5	1. Submittal of general arrangement drawings	0 d	30/11
6	2. Each major subsystem contractor placed under contract	0 d	10/01
7	**3. Preliminary and final design reviews of each major subsystem**	40 d	
8	Preliminary design reviews of each major subsystem	0 d	15/02
9	Final design reviews of each major subsystem	0 d	17/04
10	**4. First Article inspections of major subsystems and components**	20 d	
11	Doors	0 d	19/09
12	HVAC	0 d	19/09
13	Auxiliary Electrical Equipment	0 d	05/09
14	Propulsion System and Control	0 d	05/09
15	Friction Brake System	0 d	05/09
16	Vehicle Communications	0 d	03/10
17	5. Commence first streetcar shell parts manufacture	0 d	21/05
18	6. Commence first streetcar shell major assembly	0 d	18/06
19	7. Complete first bare streetcar shell prior to painting	0 d	29/06
20	8. Vehicle shell static load test	0 d	19/10
21	9. Complete first streetcar set of truck frames	0 d	05/10
22	10. Truck frame fatigue test	0 d	14/01
23	11. Ship first streetcar shell to final assembly site, if separate	0 d	25/10
24	12. Commence first streetcar final assembly	0 d	20/12
25	13. Complete equipment installation on first streetcar	0 d	29/04
26	14. Final truck mounting on first streetcar	0 d	06/05
27	15. First Article inspection of first streetcar	0 d	28/08
28	**16. Completion of each vehicle shell**	199 d	
29	1st Streetcar	0 d	19/09
30	2nd Streetcar	0 d	19/07
31	3rd Streetcar	0 d	15/11
32	4th Streetcar	0 d	09/01
33	5th Streetcar	0 d	13/02
34	6th Streetcar	0 d	15/03
35	7th Streetcar	0 d	08/04
36	8th Streetcar	0 d	07/05
37	9th Streetcar	0 d	29/05
38	10th Streetcar	0 d	20/06
39	**17. Complete final assembly and begin routine testing of each vehicle**	116 d	
40	2nd Streetcar	0 d	06/06
41	3rd Streetcar	0 d	05/07
42	4th Streetcar	0 d	12/09
43	5th Streetcar	0 d	03/10
44	6th Streetcar	0 d	01/11
45	7th Streetcar	0 d	18/11
46	8th Streetcar	0 d	03/12
47	9th Streetcar	0 d	17/12
48	10th Streetcar	0 d	03/01
49	**18. Shipment and arrival of each vehicle at Authority's facility**	125 d	
50	1st Streetcar	0 d	11/09
51	2nd Streetcar	0 d	10/10
52	3rd Streetcar	0 d	08/11
53	4th Streetcar	0 d	09/12
54	5th Streetcar	0 d	31/12
55	6th Streetcar	0 d	23/01
56	7th Streetcar	0 d	07/02
57	8th Streetcar	0 d	21/02
58	9th Streetcar	0 d	09/03
59	10th Streetcar	0 d	24/03
60	**19. Contractual delivery of each vehicle (turnover to the Authority)**	125 d	
61	1st Streetcar	0 d	18/09
62	2nd Streetcar	0 d	18/10
63	3rd Streetcar	0 d	18/11
64	4th Streetcar	0 d	16/12
65	5th Streetcar	0 d	08/01
66	6th Streetcar	0 d	30/01
67	7th Streetcar	0 d	14/02
68	8th Streetcar	0 d	28/02
69	9th Streetcar	0 d	16/03
70	10th Streetcar	0 d	31/03
71	**20. Reliability Demonstration Program**	0 d	+3 years in case of gear units, couplings, traction motors, and propulsion equipment 28/04

Project: PROPOSER'S SCHEDULE F
Date: 11/04/2017

Task | Milestone ◆ | Summary

SUPPLY OF 10 STREETCARS FOR THE CITY OF SEATTLE

- PROPOSER'S SCHEDULE -

Id	Task Name	Duration	Start	Finish
72	**ENGINEERING**	**210 d**		
73	Basic Engineering	70 d	04/09	18/12
74	**CARBODY**	**110 d**		
75	Underframe Design	90 d	16/11	06/04
76	Carbody Design	100 d	30/11	11/05
77	Definition Profile Material	0 d	18/12	
78	**SYSTEMS**	**165 d**		
79	Specifications	40 d	04/09	31/10
80	Selection of Suppliers	20 d	02/11	29/11
81	Purchase Orders	20 d	30/11	10/01
82	Interface 1- Systems Interface Basic Definition	25 d	11/01	15/02
83	Interface 2- Systems Interface Complete Definition	40 d	16/02	17/04
84	Electrical and Functional Schematics	20 d	18/04	18/05
85	**INSTALLATIONS**	**125 d**		
86	Underframe Equipments	70 d	19/12	06/04
87	Roof Equipments	60 d	04/01	30/03
88	Saloon Equipments	60 d	11/01	06/04
89	Electrical Box	50 d	09/02	25/04
90	Electrical Duct	50 d	12/03	25/05
91	Cab Equipments	40 d	26/03	25/05
92	Other Equipments	40 d	26/03	25/05
93	Electrical Cabling & Wiring Design	30 d	21/05	29/06
94	**VEHICLE FINISHING**	**95 d**		
95	Passenger Acces Door Assembly	0 d	17/04	
96	**WINDOWS & ACCESSORIES**	**30 d**		
97	Release Windows & Windscreen Specifications for procurement	0 d	01/03	
98	Windows & Windscreen	30 d	02/03	17/04
99	**INSULATION**	**50 d**		
100	Release of Insulation Specifications for Procurement	0 d	17/04	
101	Insulation	50 d	18/04	29/06
102	**FLOOR LINING**	**50 d**		
103	Release Floor Specifications for Procurement	0 d	17/04	
104	Floor Lining, Panels & Floor Insulation	30 d	21/05	29/06
105	**SALOON LINING**	**20 d**		
106	Side Lining	20 d	21/05	15/06
107	Roof Lining	15 d	21/05	08/06
108	**CAB LINING**	**45 d**		
109	Side Lining	35 d	21/05	06/07
110	Roof Lining	25 d	21/05	22/06
111	Other Assemblies	20 d	25/06	20/07
112	**SEATS**	**30 d**		
113	Release Seats Specifications for Procurement	0 d	21/05	
114	Driver's Seat Assemblies	30 d	21/05	29/06
115	Passenger's Seats Assemblies	30 d	21/05	29/06
116	**TRUCKS**	**180 d**		
117	Structure	70 d	16/10	06/02
118	Wheelset	50 d	07/02	20/04
119	Finishing	60 d	24/04	18/07
120	**PROCUREMENT (STREETCAR #1)**	**286 d**		
121	Manufacturing & Purchasing - Supplier Activities	140 d	18/04	30/10
122	Delivery of Preassemblies Components	30 d	03/09	12/10
123	Delivery of Equipment for Streetcar #1	60 d	31/10	22/01
124	**OTHERS COMPONENTS & MATERIALS**	**284 d**		
125	Manufacturing of Raw Material	80 d	19/12	09/04
126	Delivery of Raw Material for Bodyshells	10 d	10/04	23/04
127	Carbody Components	35 d	10/04	28/05
128	Installations Components	50 d	20/08	26/10
129	Interiors & Finishing Components	70 d	15/10	18/01
130	**TRUCK PROCUREMENT**	**216 d**		
131	Materials for Truck Frame	75 d	07/02	22/05
132	Materials for Truck Wheelset	110 d	23/04	21/09
133	Materials for Truck Finishing Assemblies	100 d	19/07	05/12

Project: PROPOSER'S SCHEDULE F
Date: 11/04/2017

Task | Milestone ◆ | Summary

SUPPLY OF 10 STREETCARS FOR THE CITY OF SEATTLE

- PROPOSER'S SCHEDULE -

Id	Task Name	Duration	Start	Finish
134	**VEHICLE SHELLS MANUFACTURING (IN SPAIN)**	297 d		
135	**JIGS & TOOLING MANUFACTURING**	45 d		
136	Underframe Tooling	25 d	09/04	18/05
137	Bodyshell Tooling	25 d	14/05	15/06
138	**STREETCAR #1**	78 d		
139	**CARBODY MANUFACTURING**	29 d		
140	1st Carbody Manufacturing	15 d	10/07	30/07
141	1st Carbody Inspection (Dimensional & Welding)	0 d		30/07
142	2nd Carbody Manufacturing	15 d	19/07	10/09
143	2nd Carbody Inspection (Dimensional & Welding)	0 d		10/09
144	3rd Carbody Manufacturing	15 d	30/07	19/09
145	3rd Carbody Inspection (Dimensional & Welding)	0 d		19/09
146	Painting & Inspection	15 d	20/09	10/10
147	Disassembly - CKD Formation	14 d	11/10	24/10
148	Tranport to CAF-USA	35 d	25/10	28/11
149	**STREETCAR #2**	129 d		
150	**CARBODY MANUFACTURING**	44 d		
151	**1st CARBODY MANUFACTURING**	30 d		
152	Underframe's subassemblies	10 d	21/05	01/06
153	Underframe Assembly & Welding	10 d	04/06	15/06
154	Underframe FAI	0 d		15/06
155	Carbody's subassemblies	10 d	18/06	29/06
156	Sidewall Inspection	0 d		29/06
157	Roof Inspection (Dimensional & Welding & Clinching)	0 d		29/06
158	1st Carbody Inspection (Dimensional & Welding)	0 d		29/06
159	2nd Carbody Manufacturing	15 d	20/06	10/07
160	2nd Carbody Inspection (Dimensional & Welding)	0 d		10/07
161	3rd Carbody Manufacturing	15 d	29/06	19/07
162	3rd Carbody Inspection (Dimensional & Welding)	0 d		19/07
163	Special Test: Static Load Test on 1st Vehicle	42 d	20/07	19/10
164	Painting & Inspection	15 d	22/10	09/11
165	Disassembly - CKD Formation	14 d	10/11	23/11
166	Tranport to CAF-USA	35 d	24/11	28/12
167	**STREETCAR #3**	72 d		
168	Carbody Manufacturing	30 d	04/10	15/11
169	Painting & Inspection	15 d	16/11	10/12
170	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	11/12	28/01
171	**STREETCAR #4**	78 d		
172	Carbody Manufacturing	30 d	15/11	09/01
173	Painting & Inspection	15 d	10/01	30/01
174	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	31/01	20/03
175	**STREETCAR #5**	76 d		
176	Carbody Manufacturing	30 d	02/01	13/02
177	Painting & Inspection	15 d	14/02	08/03
178	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	09/03	26/04
179	**STREETCAR #6**	75 d		
180	Carbody Manufacturing	30 d	31/01	15/03
181	Painting & Inspection	15 d	18/03	05/04
182	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	06/04	24/05
183	**STREETCAR #7**	80 d		
184	Carbody Manufacturing	30 d	22/02	08/04
185	Painting & Inspection	15 d	09/04	06/05
186	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	07/05	24/06
187	**STREETCAR #8**	80 d		
188	Carbody Manufacturing	30 d	20/03	07/05
189	Painting & Inspection	15 d	08/05	28/05
190	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	29/05	16/07
191	**STREETCAR #9**	75 d		
192	Carbody Manufacturing	30 d	11/04	29/05
193	Painting & Inspection	15 d	30/05	19/06
194	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	20/06	07/08
195	**STREETCAR #10**	59 d		
196	Carbody Manufacturing	30 d	10/05	20/06
197	Painting & Inspection	15 d	21/06	11/07
198	Disassembly - CKD Formation - Tranport to CAF-USA	49 d	12/07	29/08
199	**TRUCKS MANUFACTURING (STREETCAR #1)**	204 d		
200	Frames Manufacturing (in Spain)	75 d	23/05	05/10
201	Wheelset Manufacturing (in Spain)	60 d	08/10	14/01
202	Transport to CAF-USA	49 d	15/01	04/03
203	**FINISHING (in USA)**	30 d		
204	Z1 Position	10 d	05/03	18/03
205	Z2 Position	10 d	19/03	01/04
206	Z3 Position	10 d	02/04	15/04
207	Trucks Testing	10 d	16/04	29/04
208	1st Streetcar Trucks delivery to assembly line	0 d		29/04

Project: PROPOSER'S SCHEDULE F
Date: 11/04/2017

Task | Milestone ◆ | Summary

SUPPLY OF 10 STREETCARS FOR THE CITY OF SEATTLE

- PROPOSER'S SCHEDULE -

Id	Task Name	Duration	Start	Finish
209	**STREETCAR FINISHING (IN USA)**	346 d		
210	**STREETCAR #1**	215 d		
211	**1st CAR FINISHING (C1)**	130 d		
212	Carbodies delivered to CAF-USA	0 d	28/11	
213	Carbody re-assembly, checks & inspections	15 d	29/11	19/12
214	P1 (Electrical Pre-Assemblies Position)	40 d	25/10	19/12
215	P3 (Roof Position)	30 d	20/12	01/02
216	P4 (Cab Position)	30 d	20/12	01/02
217	Z1 Position	30 d	20/12	01/02
218	Z2 Position	30 d	04/02	18/03
219	Z3 Position	30 d	19/03	29/04
220	**2nd CAR FINISHING (S)**	90 d		
221	P3 (Roof Position)	30 d	20/12	01/02
222	Z1 Position	30 d	20/12	01/02
223	Z2 Position	30 d	04/02	18/03
224	Z3 Position	30 d	19/03	29/04
225	**3rd CAR FINISHING (C2)**	95 d		
226	P3 (Roof Position)	30 d	20/12	01/02
227	P4 (Cab Position)	30 d	20/12	01/02
228	Z1 Position	30 d	20/12	01/02
229	Z2 Position	30 d	04/02	18/03
230	Z3 Position	30 d	19/03	29/04
231	Carbody/Truck Integration	5 d	30/04	06/05
232	Factory Tests	80 d	07/05	28/08
233	**STREETCAR #2**	188 d		
234	Car Finishing	105 d	31/12	30/05
235	Carbody/Truck Integration	5 d	31/05	06/06
236	Static Factory Tests	15 d	07/06	27/06
237	Dynamic Factory Tests (Pre-OESS)	18 d	28/06	24/07
238	Special Test: OESS System	25 d	25/07	28/08
239	Dynamic Factory Tests	20 d	29/08	26/09
240	**STREETCAR #3**	188 d		
241	Car Finishing	105 d	30/01	27/06
242	Carbody/Truck Integration	5 d	28/06	05/07
243	Pre-HVAC Factory Tests	8 d	08/07	17/07
244	Special Test: HVAC / Climatic Chamber	30 d	18/07	28/08
245	Factory Tests	40 d	29/08	25/10
246	**STREETCAR #4**	155 d		
247	Car Finishing	100 d	16/04	05/09
248	Carbody/Truck Integration	5 d	06/09	12/09
249	Factory Tests	50 d	13/09	25/11
250	**STREETCAR #5**	145 d		
251	Car Finishing	90 d	21/05	26/09
252	Carbody/Truck Integration	5 d	27/09	03/10
253	Factory Tests	50 d	04/10	17/12
254	**STREETCAR #6**	140 d		
255	Car Finishing	90 d	19/06	25/10
256	Carbody/Truck Integration	5 d	28/10	01/11
257	Factory Tests	45 d	04/11	09/01
258	**STREETCAR #7**	130 d		
259	Car Finishing	80 d	18/07	08/11
260	Carbody/Truck Integration	5 d	12/11	18/11
261	Factory Tests	45 d	19/11	24/01
262	**STREETCAR #8**	130 d		
263	Car Finishing	80 d	01/08	25/11
264	Carbody/Truck Integration	5 d	26/11	03/12
265	Factory Tests	45 d	04/12	07/02
266	**STREETCAR #9**	130 d		
267	Car Finishing	80 d	15/08	10/12
268	Carbody/Truck Integration	5 d	11/12	17/12
269	Factory Tests	45 d	18/12	24/02
270	**STREETCAR #10**	130 d		
271	Car Finishing	80 d	30/08	26/12
272	Carbody/Truck Integration	5 d	27/12	03/01
273	Factory Tests	45 d	06/01	10/03

Project: PROPOSER'S SCHEDULE F
Date: 11/04/2017

Task — Milestone ◆ — Summary

SUPPLY OF 10 STREETCARS FOR THE CITY OF SEATTLE

- PROPOSER'S SCHEDULE -

Id	Task Name	Duration	Start	Finish
274	**STREETCAR DELIVERY & ACCEPTANCE**	168 d		
275	**STREETCAR #1**	74 d		
276	Transport to Authority's facility	14 d	29/08	11/09
277	Check after Arrival	5 d	12/09	18/09
278	**Contractual Delivery Streetcar #1**	0 d		18/09
279	Pre-Operational Tests On Track	20 d	19/09	17/10
280	**Substantial Completion Streetcar #1**	0 d		17/10
281	Burn-in Test	40 d	18/10	16/12
282	**Conditional/Final Acceptance Streetcar #1**	0 d		16/12
283	**STREETCAR #2**	75 d		
284	Transport to Authority's facility	14 d	27/09	10/10
285	Check after Arrival	5 d	11/10	18/10
286	**Contractual Delivery Streetcar #2**	0 d		18/10
287	Pre-Operational Tests On Track	20 d	21/10	18/11
288	**Substantial Completion Streetcar #2**	0 d		18/11
289	Burn-in Test	40 d	19/11	16/01
290	**Conditional/Final Acceptance Streetcar #2**	0 d		16/01
291	**STREETCAR #3**	65 d		
292	Transport to Authority's facility	14 d	26/10	08/11
293	Check after Arrival	5 d	12/11	18/11
294	**Contractual Delivery Streetcar #3**	0 d		18/11
295	Pre-Operational Tests On Track	20 d	19/11	17/12
296	**Substantial Completion Streetcar #3**	0 d		17/12
297	Burn-in Test	30 d	18/12	31/01
298	**Conditional/Final Acceptance Streetcar #3**	0 d		31/01
299	**STREETCAR #4**	54 d		
300	Transport to Authority's facility	14 d	26/11	09/12
301	Check after Arrival	5 d	10/12	16/12
302	**Contractual Delivery Streetcar #4**	0 d		16/12
303	Pre-Operational Tests On Track	20 d	17/12	15/01
304	**Substantial Completion Streetcar #4**	0 d		15/01
305	Burn-in Test	20 d	16/01	13/02
306	**Conditional/Final Acceptance Streetcar #4**	0 d		13/02
307	**STREETCAR #5**	54 d		
308	Transport to Authority's facility	14 d	18/12	31/12
309	Check after Arrival	5 d	02/01	08/01
310	**Contractual Delivery Streetcar #5**	0 d		08/01
311	Pre-Operational Tests On Track	20 d	09/01	06/02
312	**Substantial Completion Streetcar #5**	0 d		06/02
313	Burn-in Test	20 d	07/02	06/03
314	**Conditional/Final Acceptance Streetcar #5**	0 d		06/03
315	**STREETCAR #6**	49 d		
316	Transport to Authority's facility	14 d	10/01	23/01
317	Check after Arrival	5 d	24/01	30/01
318	**Contractual Delivery Streetcar #6**	0 d		30/01
319	Pre-Operational Tests On Track	15 d	31/01	21/02
320	**Substantial Completion Streetcar #6**	0 d		21/02
321	Burn-in Test	20 d	24/02	20/03
322	**Conditional/Final Acceptance Streetcar #6**	0 d		20/03
323	**STREETCAR #7**	45 d		
324	Transport to Authority's facility	14 d	25/01	07/02
325	Check after Arrival	5 d	10/02	14/02
326	**Contractual Delivery Streetcar #7**	0 d		14/02
327	Pre-Operational Tests On Track	15 d	18/02	09/03
328	**Substantial Completion Streetcar #7**	0 d		09/03
329	Burn-in Test	15 d	10/03	30/03
330	**Conditional/Final Acceptance Streetcar #7**	0 d		30/03
331	**STREETCAR #8**	44 d		
332	Transport to Authority's facility	14 d	08/02	21/02
333	Check after Arrival	5 d	24/02	28/02
334	**Contractual Delivery Streetcar #8**	0 d		28/02
335	Pre-Operational Tests On Track	15 d	02/03	20/03
336	**Substantial Completion Streetcar #8**	0 d		20/03
337	Burn-in Test	15 d	23/03	10/04
338	**Conditional/Final Acceptance Streetcar #8**	0 d		10/04
339	**STREETCAR #9**	40 d		
340	Transport to Authority's facility	14 d	25/02	09/03
341	Check after Arrival	5 d	10/03	16/03
342	**Contractual Delivery Streetcar #9**	0 d		16/03
343	Pre-Operational Tests On Track	15 d	17/03	06/04
344	**Substantial Completion Streetcar #9**	0 d		06/04
345	Burn-in Test	10 d	07/04	20/04
346	**Conditional/Final Acceptance Streetcar #9**	0 d		20/04
347	**STREETCAR #10**	35 d		
348	Transport to Authority's facility	14 d	11/03	24/03
349	Check after Arrival	5 d	25/03	31/03
350	**Contractual Delivery Streetcar #10**	0 d		31/03
351	Pre-Operational Tests On Track	10 d	01/04	14/04
352	**Substantial Completion Streetcar #10**	0 d		14/04
353	Burn-in Test	10 d	15/04	28/04
354	**Conditional/Final Acceptance Streetcar #10**	0 d		28/04
355	**CONTRACTUAL CONDITIONAL ACCEPTANCE (All Streetcars)**	0 d		30/04

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Sub-Part C – MANAGEMENT APPROACH AND SCHEDULE

SECTION F COMPREHENSIVE SCHEDULE WITH KEY MILESTONES

CAF uses project software to configure all aspects of the project and to ensure that all Contractual Scheduling Milestones for the Center City Connector Streetcar Vehicles Procurement will be met. The latest version of Microsoft Project or Primavera Planner software is used for scheduling the different phases that are involved in a Project, which basically are Designing, Purchasing, Manufacturing, Testing, Shipping, Delivery and Acceptance, and the Critical Path Method is applied.

1.A. SCHEDULE PROPOSAL FOR CENTER CITY CONNECTOR

CAF's proposed Project Schedule for the supply of ten Streetcars for the City of Seattle is included at the end of this Section as Appendix CF.1 Project Schedule Proposal. With CAF's previous experience in the design, manufacturing and testing of other similar projects, this Schedule and the included activity durations have been developed to ensure achievement of the Main Contract Requirements.

Main Contract requirements for this project are the following:

- Conditional Acceptance of all Vehicles NTP + 32 months
- Completion of spare parts delivery NTP + 24 months
- Delivery of all test equipment and special tools NTP + 24 months

1.A.1. CONCEPTUAL DESIGN

In the Basic Engineering phase, CAF will define any new design concepts required by SDOT, and kick off the systems integration and systems assurance tasks. The Engineering Design is along the schedule's Critical Path up to the start of car's systems design.

Other important schedule milestones within the Engineering Design period include submittal of the general arrangement drawings, Baseline Project Schedule, Management and Quality plan.

1.A.2. CARBODY DESIGN

After conceptual design, the next activity along the critical path is the generating of the List of Profiles. Those Profiles procurement and delivery are necessary to begin manufacturing of the first carshell.

The schedule's Critical Path continues through design of the carbody's underframe and structural subassemblies. This segment of the Critical Path concludes once the carbody design advances to the preparation of production jigs and tooling.

In this design stage, the carbody design engineers and manufacturing engineers work closely together, to facilitate the efficient design of the jigs and tooling. The carbody engineers assist in this process through the use of 3-D modeling of the principal car shell subassemblies.

Carbody design tasks will continue along the schedule's Critical Path.

1.A.3. SYSTEM PROCUREMENT

After the NTP and in parallel with basic engineering and carbody design, First Vehicle Subsystem procurement is the next phase on the Critical Path.

CAF closely controls the procurement, production, testing, and delivery of the major systems to support the carbody final assembly schedule. Most of the systems procurement is along the Critical Path. CAF always considers the procurement, design, interface, integration, qualification, FAI and delivery of the propulsion subsystem as critical to the project schedule.

The majority of the system suppliers that were established as suppliers of the equipment for The City of Cincinnati and City of Kansas City, MO projects will provide the equipment for the Center City Connector. After procurement orders have been established, CAF System engineers will begin work on both the basic and complete definition of the system and, in parallel, subcontractors will start the manufacturing, purchasing and testing of their systems.

With the similarity of the Center City Connector vehicles to the Cincinnati and Kansas City vehicles, many of the tasks involved in this step will have been completed previously during those procurements.

CAF will conduct FAIs for all major systems and components according to pre-established schedules.

1.A.4. CARSHELL MANUFACTURING

Once the design and related structural analyses are approved, different frame and carshell subassemblies are prepared (sides, underframe, roof, etc.).

Manufacture of the first carbody is on the schedule's Critical Path. The frame and bodyshell subassemblies will require the design of new manufacturing jigs and tooling.

During this stage, CAF will refine the carbody manufacturing, inspection, and test procedures. Manufacturing engineers will work with the carbody design engineers to improve the carbody designs. Key steps on the Critical Path in this stage include welding procedure development and approval, jig design and approval, manufacture of frame subassembly components, frame construction and FAI. Time efficiencies gained through the manufacturing of previous contracts will be incorporated into the Schedule.

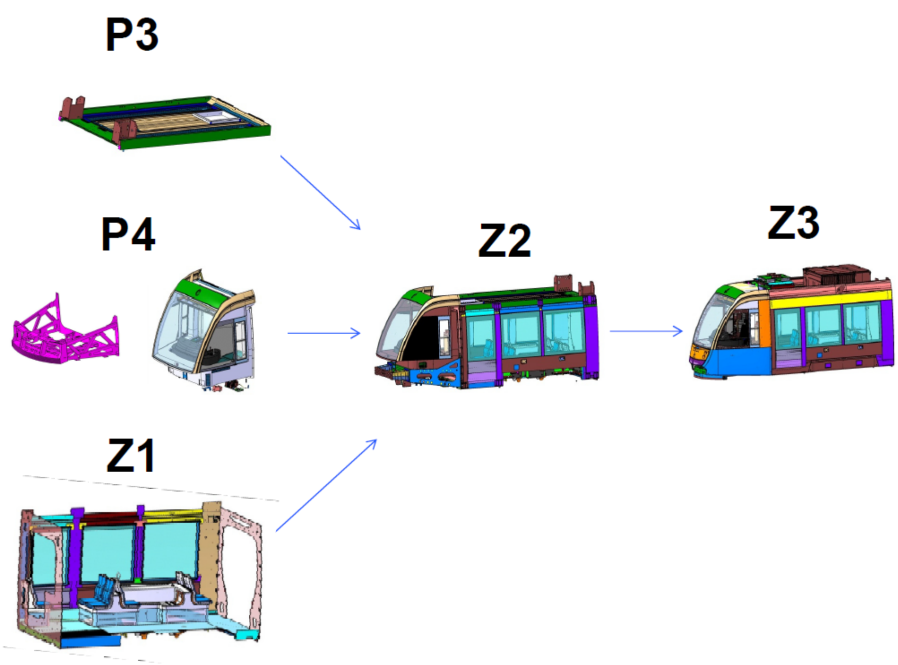


1.A.5. VEHICLE FINISHING

Following the manufacture of each carbody and after successful completion of the Structural Test, painted vehicle shells from the second vehicle will be disassembled, loaded into a container (CKD Formation) and transported to Elmira (NY) in order to be reassembled in the Final Assembly line.

CAF will conduct the car body final assembly tasks at three (3) consecutive work stations. Final assembly of the first vehicle at these work stations is part of the schedule's Critical Path.

Wiring is a key activity in the car final assembly process. Wiring is a critical stage that, once completed, allows the rest of assembly and finishing work to proceed.



1.A.6. TRUCKS FOR FIRST VEHICLE

Trucks for the first vehicle must be available in time for the scheduled truck-to-car body coupling activity.

Lead time for the design, analysis, construction and FAI of the trucks is considerably less than that required for the construction of the first car. Therefore, these important project milestones are not part of the Critical Path.

1.A.7. FACTORY TESTING

After the final assembly tasks for each streetcar are completed, the next activity along the Critical Path is the first vehicle Factory testing and inspection.

CAF already has in place all of the testing facilities and equipment necessary to complete the factory static tests of the vehicles.

1.A.8. TESTING AT MAINLINE TRACKS OF SDOT'S SYSTEM

After the delivery of the vehicle with all of the equipment installed, on the receiving track at SDOT's facility, the next step along the Critical Path is Acceptance Testing on the first vehicle. Final Acceptance after testing completes all the tasks included within the Schedule and fulfills the delivery requirements.

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Sub-Part D – SYSTEM SUPPORT PLAN

Sub-Part D – System Support Plan

SECTION A QUALITY ASSURANCE AND SPEC REQUIREMENTS

1.A. QUALITY ASSURANCE PLAN

Since 1990, CAF has been working on a Quality Management system aligned with ISO 9001. The first certification was achieved in 1994, according to ISO 9001:1994 standard. The scope of the certificate is: “Design, manufacturing, servicing, repairing/transforming and maintenance of railway vehicles and bogies”. In 2003, the CAF Quality Management system was adapted to the standard EN-ISO 9001:2000 and currently is ISO 9001:2008 and IRIS rev.02 certified.

CAF is also ISO 14001 and BS OSHAS 18001 certified. Additionally, CAF wheels and axles Business Unit (CAF Miira) is AAR M-1003 and IRIS certified as well.

CAF will submit a project-specific Quality Assurance Program Plan (QAPP) (known within CAF as the “Quality Plan”) for approval. The QAPP will provide objective technical evidence of the adequacy of the Contractor’s Quality Assurance Program to ensure product compliance.

Engineering, procurement, manufacturing, inspection and test procedures and plans applicable to the project and required to ensure compliance with all contract requirements, will be developed using the methods and procedures established in CAF’s Quality Manual, and listed in the QAPP.

The QAPP will include a company policy statement that clearly defines its objectives and commitment to quality.

The QAPP will be developed following the ISO 10005 standard (guidelines for quality plans), which gathers all the requirements of ISO 9001.

This Plan includes all items from CAF’s Quality System such as: Description of the project, Quality system, Management responsibilities, Contract Review, Design Control, Document and Data Control, Purchasing, Control of Customer Supplied Products, Product Identification and Traceability, Process Control, Inspection and Testing and Test Status, Inspection Measuring and Test Equipment, Nonconforming Products and Corrective Actions, Handling Storage Packaging and Delivery, Quality Records, Quality Audits, Training, and After-sales Service.

1.A.1. QUALITY ASSURANCE MANUAL

CAF’s Quality Assurance Manual (known as the “Quality Manual” within CAF) is ISO 9001:2008 and IRIS Rev.02 certified. The Quality Manual lists CAF’s procedures (see list of procedures in Figure 15) that describe the methods for planning, implementing, and maintaining quality assurance.

The Quality Manual contains all the elements to comply with ISO 9001:2008 and IRIS Rev.02 standards requirements. Therefore, the procedures and statements included in the Quality Manual are mandatory for all CAF projects and activities.

After NTP, CAF will submit the latest edition of the Quality Manual in the (mandatory).

All of these activities are shown below in the Quality Assurance Flow Chart, see Figure 1 below.

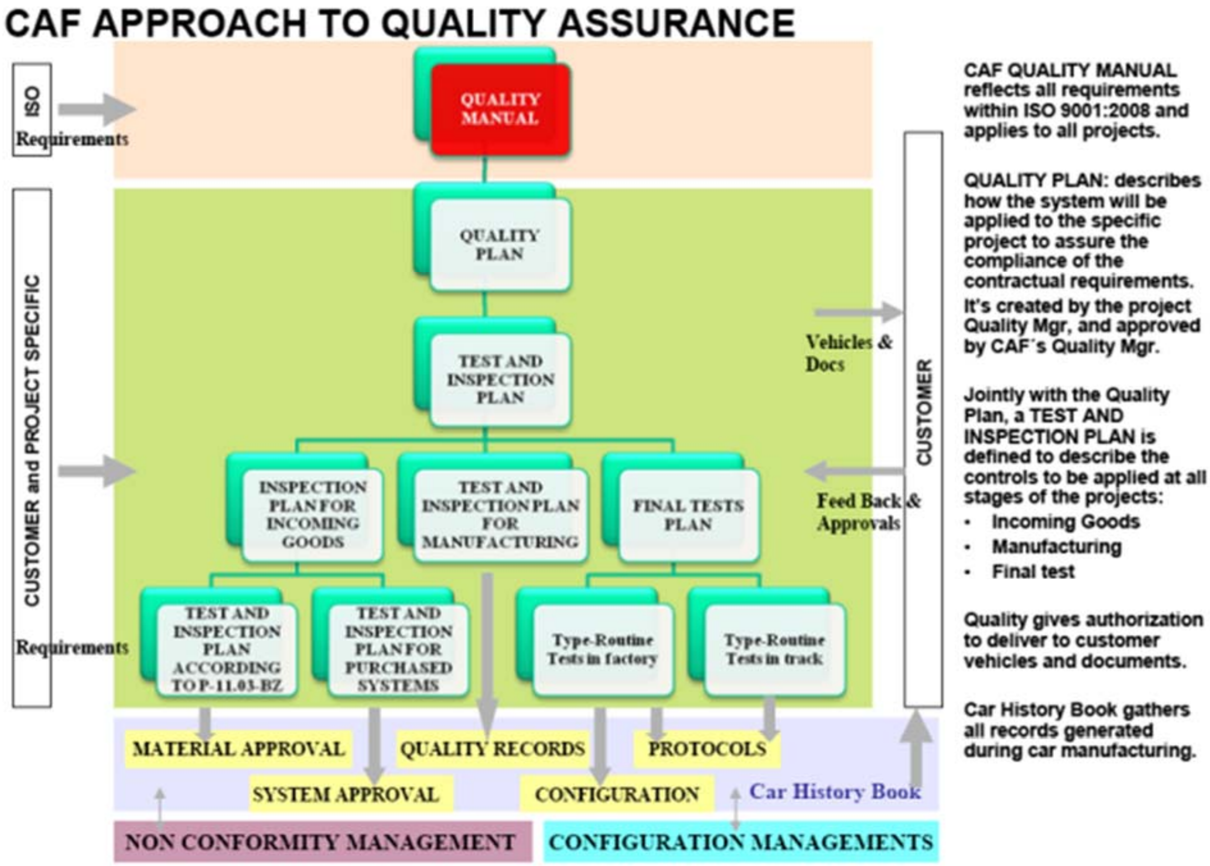

Figure 1. Quality Assurance Flowchart

1.B. QUALITY ASSURANCE OF THE DESIGN

The Project Quality Assurance Program Plan describes the planning of Design and Development activities in CAF. These plans are subject to monitoring and updating as the design develops.

It is CAF's standard procedure to perform periodic in-progress reviews. More specifically, the following reviews will be conducted: Conceptual Design Review (CDR), Preliminary Design Review (PDR) and Final Design Review (FDR). The objective of this process is to capitalize on the expertise of CAF's staff and obtain input and feedback from their previous manufacturing experiences to ensure that all customer expectations and requirements are met.

In addition to this main objective, the design reviews may also target i) the compatibility among assemblies, items and systems, as well as functional and physical interactions between items ii) the strength of the design against variability of processes iii) the criticality of the product and its effect on failures and regarding safety and iv) the internal CAF requirements (Special processes, environmental aspects, RAMS, previous design feedback, etc.).

These items may be added in BERDE, or may be reviewed separately, depending on the scope of the points to be reviewed and on the Project Manager's criteria.

Design reviews are carried out in the following three phases:

CONCEPTUAL DESIGN REVIEW

The conceptual design review will be carried out during the initial Project phase, once the Requirements Database is established (BERDE), following CAF's internal procedure P-05.02-BZ "Design Development". It is held once the Basic Engineering has been finished. In the conceptual design revision, those requirements indicated in BERDE will be reviewed.

PRELIMINARY DESIGN REVIEW

The preliminary design review will be carried out during the main phase of the Detailed Engineering. As for the conceptual design revision, those requirements indicated on the BERDE will be reviewed.

FINAL DESIGN REVIEW

This is the last phase of the design revision, where the results of the previous design revisions will be confirmed. The final design revision takes place at the finalization of the last 3D or significant document that make up the design stage.

1.B.1. DESIGN VERIFICATION PLAN

A Project Design Verification Plan based on DOORS© (Dynamic Object Oriented Requirements System) software is defined in order to specify the methods used by CAF to verify each Design Package and ensure that it has been designed in accordance with the requirements of the project agreement.

The steps that are followed in the design verification plan are:

- Design review (Concept design, Preliminary design, Final design)
- Monitoring of design verifications
- Validation of design by testing

1.B.2. MODIFICATIONS AND CONFIGURATION MANAGEMENT

A specific configuration management plan is developed in each project, in order to know at any time, which is the configuration status of the vehicles, and to define how to propose, approve, implement and track any change to the configuration.

Any CAF department may propose modifications aimed at resolving design non-conformities or propose improvements to processes or products.

All changes are subjected, prior to their launch and implementation, to a technical review and approval by the Design Team and to an impact evaluation and eventual approval by the Project Team. Customer is consulted when appropriate or as agreed upon. CAF maintains a full traceability of design changes and continuous monitoring of their actual implementation status.

Any modification is identified with a modification number and a project code, and, by default, is associated to a Design Review Group at Engineering Department. Depending on the origin of the change, CAF distinguishes two groups of modifications: ones raised by CAF and the ones raised by SDOT.

1.B.3. DEVIATION MANAGEMENT

CAF has defined a system to ensure that products not conforming to the established requirements are identified, controlled and segregated from the production flow.

The system applies to all areas and processes within CAF, from the design to the vehicle commissioning.

Any non-conforming material detected will be clearly identified and segregated to avoid its use and a Non-Conformance Report (NCR) document will be created. Non-compliant or defective materials will be kept in the “NCR Area” until final disposition: scrap, return to supplier, repair or use as is. For rework or use “as is” dispositions, written authorization will be required from SDOT.

1.B.4. INSPECTION AND TEST PLAN

After NTP, CAF will submit the Inspection and Test Plan (ITP) for approval. According to the QAPP, an Inspection and Test Plan will be defined to identify the controls to be applied during all stages of the project. This Inspection and Test Plan will include:

- Inspection and Test Plan for Incoming Goods.
- Inspection and Test Plan for Manufacturing.
- Final Tests Plan (including factory and in-track testing).

1.B.5. PURCHASING

The suppliers of the products or services and subcontractors with an effect on the quality of the final product are evaluated and selected considering their ability to satisfy the specified requirements. The evaluation system contemplates Initial Approval, Periodical Evaluation and Updating of the List of Approved Subcontractors and Suppliers, and Buy America provisions.

In addition, CAF and/or SDOT will be allowed to conduct inspections at the supplier’s facilities, as stated in the General Purchase Conditions included in the purchase order.

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Sub-Part D – SYSTEM SUPPORT PLAN

SECTION B INCORPORATION OF SAFETY CONSIDERATIONS

CAF is thoroughly dedicated to safety; from minimizing workplace hazard, to prudent, proven methods for design and testing of our vehicles, to the maintenance and service to ensure safe vehicle operation by SDOT. Project safety management is carried out per CAF's standard RAMS Process which is part of CAF's overall quality system and incorporates the applicable safety standards and legal and contractual safety requirements. Safety activities performed throughout the life cycle of the project can be divided into five broad phases and affect all the organization's departments. Each phase is further divided into multiple steps, (see below).

The following steps are followed by CAF in the safety justification process regarding the subsystems design and its integration into the streetcar.

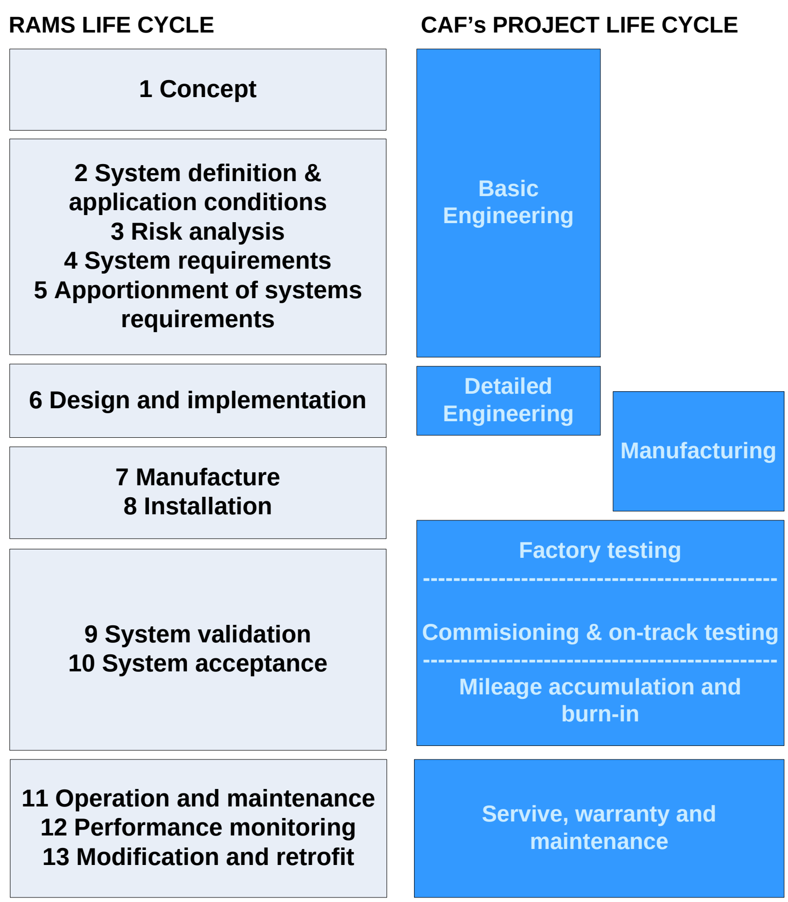

Figure 1. RAMS Life Cycle

1.A. BASIC DESIGN

In the Basic Design phase, the first safety analyses at vehicle levels are carried out by the System Safety Engineer: Hazard List, PHA and Safety Critical Item List. These analyses allow CAF to define the high-level mitigation measures for hazards with an initial risk assessment value higher than the criteria defined within the applicable standard. These mitigation measures can be of the following types:

- Safety Related Requirement (SRR): Requirements that could affect the design (design selection, safety devices, warning devices), the quality, and manufacture of the Vehicle.
- Safety Related Application Conditions (SRAC): Mitigations adopted by third parties, such as the Maintainer, the Operator and / or the Infrastructure Owner.

The management of the design SRRs is performed using the Engineering Requirements Data Base (BERDE). The RAMS Project Manager assigns the safety related design requirements to the Project Lead Engineer who inputs them into BERDE (Requirements tracking database). The allocation of each requirement to a subsystem level and its assignment to a responsible engineer is done in BERDE.

- Outsourced Equipment: The SRRs are assigned to the applicable subsystems and included by the Design Team in the particular supplier specifications, internal technical specification, and/or drawings for each equipment/element. These requirements are recorded in an appendix of the Contract and signed by each supplier.
- Insourced Equipment: The SRRs assigned to subsystems designed by CAF (for example the truck and the carbody) are analyzed by the responsible member of the Design Team (Truck Engineer and Carbody Structure Engineer).
- Interfaces: The SRRs related to the interfaces between the subsystems are assigned to the System Engineer.

The fulfillment of these SRRs is verified by the RAMS Project Manager. Any non-compliance is handled by the Project Lead Engineer and the engineer responsible for the SRR in question.

1.B. DETAILED DESIGN

In Detailed Design phase, the design of the Vehicle is analyzed from a safety point of view by the System Safety Engineer, utilizing safety studies such as FMECA and FTA:

- Outsourced Equipment: For outsourced subsystems, the supplier delivers the safety analyses required in the purchase contract. Those SRACs (Safety Related Application Conditions) which are transferred by the supplier to CAF by means of these studies are integrated in the Vehicle level SHA as a new SRR or SRAC (depending on its nature).
- Insourced Equipment: For subsystems designed by CAF, any other new SRR or SRAC that is discovered during the detailed safety analyses is included in the Vehicle level SHA.

As in the previous phase, the new SRRs are included in BERDE, and assigned to the appropriate person by the RAMS Project Manager. Any non-compliance is handled by the Technical Project Manager and the engineer responsible for the SRR in question.

1.C. MANUFACTURING AND TESTING

During the manufacturing and test phases, the SRR validation method is defined and verified by the RAMS Project Manager with the help of the System Safety Engineer. Once validation tests begin, the status of the SRRs is also tracked by the RAMS Project Manager.

The RAMS Project Manager ensures that the subsystems design safety has been implemented and validated properly.

1.D. SERVICE AND WARRANTY

Safety studies are considered closed, once the Safety Case and SHA have been approved.

The Safety Case is the document that includes documentation that demonstrates that the safety process was carried out during the different phases of the project life cycle. The content of the Safety Case includes as a minimum:

- Principles of the Safety Policy defined in the model VhGpDs_Mod2222 “Safety Policy”.
- Definition of responsibilities and the organization used.
- Evidence that the System Safety Program Plan was followed and managed during the project.
- Certification showing that the train is suitable for entry into passenger service.

For the approval of the Safety Case the following steps must be followed, as stated in the procedure VhGpDs_P222 “Safety Case approval”:

- The Project Safety Steering Committee holds the Safety Case closing meeting and will sign the minutes, according to model VhGpDs_Mod2221 “Minute of the meeting for approval and closing the Safety Case”. This shows the compliance of the responsibility fields of each member of the Project Safety Steering Committee. The minutes will be an Annex of the Safety Case.
- After the Technology Director reviews and agrees with the Safety Case as provided by the rest of the Project Safety Steering Committee, the Technology Director proceeds to approve the Safety Case.

Once the safety studies are closed, the RAMS Project Manager must be informed of any design changes. The RAMS Project Manager must analyze the modification in order to check whether it affects any hazard or introduces any new potential hazard.

If a modification is safety related, the RAMS Project manager must approve the modification before it can be incorporated. If the modification in question affects a hazard identified in the System Hazard

Analysis, a check must be made to ensure that the hazard risk is still acceptable. Should the RAMS Project Manager think that a modification could have a significant safety impact, the modification will be discussed with all affected parties.

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Sub-Part D – SYSTEM SUPPORT PLAN

Sub-Part D – SYSTEM SUPPORT PLAN

SECTION C ON-SITE SUPPORT DURING DELIVERY, TESTING AND THE WARRANTY PERIOD

CAF will provide Warranty Services (corrective/unplanned maintenance) for a period of one year, commencing on the Conditional Acceptance for each streetcar.

The Warranty Services will be supplied by a group of multi-disciplined professionals who specialize in different fields. To this end, as well as having extensive experience worldwide, they will undergo rigorous theoretical and practical training that takes full advantage of the construction of the unit.

The main objective of the Warranty Service is focused on achieving the contractual requirements, both during testing for integrating the vehicles into the System and during the Warranty period. These goals will be reached by:

- Supporting the manufacturing division on fine-tuning streetcar tasks before service operation begins in order to ensure that the streetcar is perfectly integrated into the system and is compliant with the reliability and availability requirements.
- Continually monitoring the behavior of all streetcars and systems.
- Fault-finding with due diligence in accordance with the procedures set out in the Manuals and Maintenance Documentation as well as mitigating, to the greatest extent possible, the risk of the fault occurring again.
- Repairing faults and investigation of root causes, in order to take appropriate action (improvements and/or modifications) to avoid their recurrence and achieve optimum reliability, maintainability and availability ratings.
- Providing all necessary spares in order to fulfill Warranty Services with the best possible performance values. CAF may potentially use the spares owned by SDOT in order to achieve better availability values. In those cases, CAF will return the borrowed goods as soon as possible.
- Managing the information gathered within the Warranty Period, by making use of a Computer based Maintenance Management System (CMMS), which allows that all information is readily available at any time.
- Establishing a Fault Notification Procedure between the Operator/Maintainer and CAF; this will permit a quicker resolution of the fault.
- Providing Technical Support at the agreed times in order to achieve maximum vehicle availability

- Acting as a permanent liaison with the Customer, offering appropriate support throughout the Warranty Period.

During the Warranty Period, CAF will provide a monthly progress report to SDOT, providing details of contract requirement compliance and analysis of each failure, and details of corrective actions taken to address any the failure.

1.A. WARRANTY SERVICE MOBILIZATION

CAF will provide qualified technical support personnel to assist SDOT. On-site staff will be available from the beginning of the track tests until the end of warranty. At the SDOT's request, CAF personnel can be available to advise SDOT on preparing maintenance facilities to accommodate the new streetcars.

At contract award CAF Rail Services division will start project mobilization. This will include the process of organizing the necessary resources and structure in the start-up of the Warranty Period in such a way that all contractual requirements are met most efficiently.

Following is a Gantt-chart to summarize the progress of mobilization. It generally illustrates the time frame of each activity and relates them accordingly.

Activity	-15month	-14month	-13month	-12month	-11month	-10month	-9month	-8month	-7month	-6month	-5month	-4month	-3month	-2month	-1month	Conditional Acceptance Certificate
Warranty Staff Recruitment			■	■	■	■	■	■	■	■	■	■	■	■		
Training Courses										■	■	■	■	■	■	
Warranty Spares Procurement	■	■	■	■	■	■	■	■	■	■	■	■				
Warranty Tools Procurement			■	■	■	■	■	■	■	■	■	■				
Store Set-Up										■	■	■	■	■	■	

Figure 1. Warranty Mobilization Schedule

1.A.1. ON-SITE MOBILIZATION PLAN

A mobilization plan will be created jointly by CAF with the Customer which will ensure that the mobilization of CAF's team will be seamless and ensure continuous operation of the depot. The main focus will be to ensure that the processes and systems are understood and the resources are available and able to deliver a safe and reliable warranty service provision from the depot.

A Depot Operation Plan, which will include issues related to Health & Safety and Environment, will be agreed between all parties and, if applicable, a Joint Working Plan will also be developed in order to clearly determine the working procedure where interfaces between different parties exist.

1.B. WARRANTY SERVICE ORGANIZATION

A Warranty Service organizational structure will be established, led by the Field Service Support/Warranty Manager. The Warranty Manager will have a number of experienced technicians, in a number proportional to the number of units involved. CAF will ensure that all requirements are carried out by a competent team, which will be comprised of:

- CAF's USA Warranty organization;
- Engineering and purchasing support from CAF's headquarters in Spain.

In determining the correct organization structure for a particular project, CAF employs certain philosophies which are regarded as critical to successful project implementation. Some practices are as follows:

- Accountability for all maintenance activities lies with the Project Manager
- Technical support led by experts in systems, with both technical and management expertise
- Versatility with multi-skilled technician supported by system specialists
- Strong communication between the Design, Engineering and Warranty teams, which fosters a good technical understanding of the vehicle and results in a beneficial effect on the Warranty Services
- Strong communication with the CAF headquarters' purchasing function to bring about efficient spares supply management and control.

1.B.1. ORGANIZATION CHART

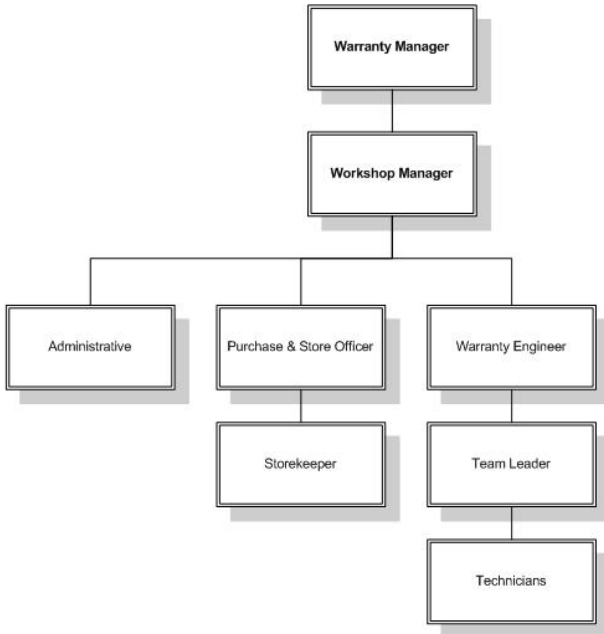

Figure 2. Warranty Team Organization Chart

Field Service Support/Warranty Manager

The Warranty Manager is responsible for the contractual delivery of the Warranty Services. This includes:

- Accountability for CAF's contractual performance and reporting on performance to the Customer;
- Project Program compliance, ensuring that all plans are produced in the required format/hierarchy/structure and contain the relevant information.

Workshop Manager

The Workshop Manager has the overall responsibility in the delivery of all activities relating to the Warranty service provision. This includes preparation and management of project plans and progress reporting and attending the Project Review Meetings. Key responsibilities include:

- Developing, managing and delivering the mobilization stages of the contract
- Project Planning, Reporting, Monitoring and Control
- Responsible for the delivery of ongoing Warranty Services
- Nominated attendee at the Project Review Meetings
- Setting up, monitoring and management of the procedures and processes required to deliver the Warranty Services for the Customer
- Ensuring that all resources are in place for the delivery of the Warranty Services

Purchase & Stores Officer

The Purchase & Stores Officer has overall management responsibility for the supply chain including external service contracts during the Warranty Service period. Key responsibilities include:

- Materials management including the optimization of stock levels and effective logistics and stores processes. This will also include management of key subcontractors
- Chairing contract reviews with the supply chain to develop relationships and address any performance issues
- All commercial relationships including development of all commercial contracts;
- Managing the process for setting up new suppliers
- Managing the warranty contracts with all suppliers
- Authorizing purchase orders

Warranty Engineer

The Warranty Engineer has overall responsibility for the delivery of the technical support services required to run the Warranty Services. This includes management of performance analysis & reporting, and management of the IT support team. Key responsibilities include:

- Fleet Performance Analysis and Reporting
- Safety Performance Analysis and Reporting
- Fault Investigation and definition of the action plan
- Performance analysis and reporting from the data recorded in the CMMS to ensure compliance with contractual requirements
- Managing reliability growth and availability performance of Units
- Development of equipment modifications and process improvements
- Providing support to the Customer in major incident investigations

The availability of the workshop staff in the depot will not be in a 24-hour basis. Depending on the shifts and the train operation, there will be telephone assistance.

1.B.2. RECRUITMENT PLAN

The warranty engineers and technicians will be recruited, as far as possible, from candidates with experience of modern trains to cover the troubleshooting and corrective work under warranty.

The recruitment selection processes will take into account personal merit, previous professional career, technical capability and suitability for the requested profile, using competency based interviews where the following factors will be assessed:

- Flexibility

- Interpersonal skills and teamwork
- Commitment to the organization
- Results orientation
- Technical ability
- Innovation / creativity
- Improvement orientation
- Client orientation
- Internal client approach

1.B.3. TRAINING PLAN

Before the team in charge of the Warranty Service begins work, members will undergo the corresponding unit technology training. The training applicable to the members of the team will be given at the following locations:

- Factories, where the unit manufacturing process itself will be used for practical sessions and for on-site vehicle familiarization
- Maintenance Centers, where the sessions related to the daily operating procedures of a similarly specified center will be held
- Different equipment manufacturing centers, in order to ensure profound and specialized understanding of the same

The training sessions will consist of theoretical and practical topics.

1.B.4. COMPETENCY MANAGEMENT

CAF will develop a Competency Management System in relation to the provision of Warranty Service, which will consider the nature of the activities to be undertaken, the frequency at which they are carried out and their importance to the safe, reliable and timely operation of the Units. The analysis will thereby provide a framework on which the competency management requirements and training needs are developed.

Skill Matrix

The Skill Matrix consists of a list including all the technicians and their corresponding skill levels divided into different systems (bogie, traction, HVAC, etc.)The goal of this document is to centralize all of the information regarding the technical competency of each technician.

CAF Rail Services	SYSTEM	MECHANICS								
	SUBSYSTEM	Bogies	Coupler	Gear Box	Ultrasounds	Wheelset	Lubrication	Hidraulic System	Welding	General Mechanics
NAME AND SURNEME	EMPLOYMENT	General Knowledge	General Knowledge	General Knowledge	Nivel I	General Knowledge	General Knowledge	General Knowledge	General Knowledge	General Knowledge
Technician 1										
Technician 2										
Technician 3										
Trainer Skilled	5	0	0	0	0	0	0	0	0	0
Expert	4	0	0	0	0	0	0	0	0	0
Good knowledge	3	0	0	0	0	0	0	0	0	0
Intermediate Knowledge	2	0	0	0	0	0	0	0	0	0
Basic Knowledge	1	0	0	0	0	0	0	0	0	0
Unkown	0	0	0	0	0	0	0	0	0	0
AVERAGE KNOWLEDGE PER SUBSYSTEM										
% EXPERTS BY SYSTEM										
AVERAGE KNOWLEDGE PER SYSTEM										
1st EXAMPLE: MECHANICAL SYSTEM OBJETIVES										
Objetive no. Technicians with level 2		5	4	5	3	4	5	5	5	5
No. Technicians >= objetive		0	0	0	0	0	0	0	0	0
No. Technicians < objetive		0	0	0	0	0	0	0	0	0

Figure 3. Skill Matrix

Continuous Competency Assessment

Taking into account the score obtained by the personnel in the Skills Matrix, regarding their skills, knowledge level and competences, CAF will design and determine the Training Program in order to organize a Training Plan for the training courses, appropriate to staff's needs, and then verify and validate their skills, performance and knowledge improvements.

1.C. WARRANTY SPARES MANAGEMENT

CAF has wide ranging experience in the procurement and management of spares for rail fleet supply projects. CAF and its subsidiary companies are key suppliers to the rail industry, and have developed proven procurement models and systems with the capability to manage spares throughout each stage of the supply chain, and throughout the lifecycle of the product.

Initial warranty spare parts to be held at Maintenance Depot will be delivered prior to the first streetcar entering into service.

The Warranty Spares can be classified as follows:

- CAF Carbody/Truck Warranty Spare Parts: As CAF is the Original Equipment Manufacturer (OEM) of the Carbody and Truck, CAF will determine the most appropriate stock of Warranty Spares based on its experience
- Main Suppliers Warranty Spare Parts: Material quantities will be studied and agreed with the main suppliers taking into consideration the equipment reliability figures and the previous experience in other projects

1.C.1. DEFINITION OF WARRANTY SPARES

CAF has a specific procedure for the preparation/definition of the warranty spare parts list for the project.

Upon signature of the contract, the Rail Services Department defines the warranty requirements.

The aim of this first contract review is to understand the requirements that may apply to the warranty support service, and promulgate them to the main suppliers. This way, the Customer assures that all contract requirements are passed back to back from the contract through to the main suppliers.

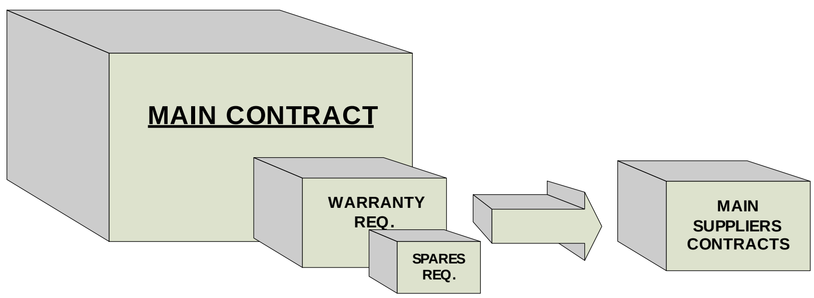

Figure 4. Warranty requirements

The warranty spares to be provided by the main suppliers have to be approved by CAF's Rail Services Department. Therefore, CAF undertakes three phases in the negotiation of this list.

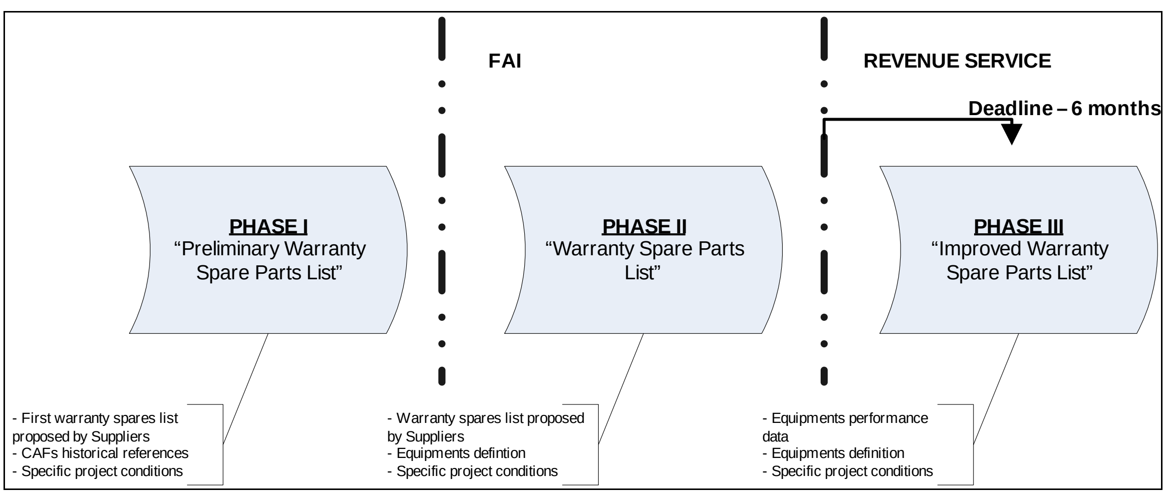

Figure 5. Phases

- PHASE I: During this first phase of development, when the train is under design, CAF evaluates the preliminary list of warranty spare parts provided by the suppliers, taking into account historical data from similar projects and the specific project conditions.
- PHASE II: Once the project reaches the point of the First Article Inspection (FAI), the train design can be considered frozen. CAF reviews all of the lists for each supplier, in order to ensure that any modifications/additions/changes made in the design of the train that can

affect the warranty spare parts list definition are implemented. Nevertheless, the aim of this "second" phase between CAF and the supplier is to review the preliminary lists, and verify the suitability of that list. MKBF/MTBF values are estimated for each piece of equipment which allows CAF to correctly define the number of warranty spares required. As a result of this phase, the Warranty Spare Parts List is defined.

- PHASE III: Once the units have entered into service, CAF can develop the spare parts requirements based on operational data. With this information, the After Sales team has the feedback from the performance metrics of the new trains and is able to determine whether the spares holding are sufficient to cover the expected usage rates. Taking into account this information, the warranty spare parts lists are revised with the purpose of "increasing" the number of spares with higher than expected usage rates. This may also highlight a requirement to open a Technical Report due to high failure rates. This topic is discussed in a separate submission.

1.C.2. WARRANTY SPARES STORAGING

CAF expects SDOT to make available an area of the existing warehouse in the maintenance depot for use by CAF to store the Warranty Spares. This area will be under CAF's control and access to it will be permitted exclusively to CAF's staff.

CAF will ensure that a system is provided and maintained to control the identification, handling, storage, packaging, preservation and delivery of products and materials to ensure no deterioration takes place:

- All spares will be clearly identified with the serial number, CAF part number, supplier part number, revision level and software revision level
- All products will be handled in a manner that minimizes the risk of damage to equipment and harm to personnel
- Each product will be stored such that damage or excessive deterioration is prevented within areas that have restricted access
- All products and materials will be stored to ensure that no degradation occurs as a result of storage, handling or delivery. Items with finite shelf lives will be identified and managed accordingly

Any materials which have special storage, handling or packing requirements will be identified and clearly tagged.

CAF ensures that any material which does not conform to product requirements is identified and controlled to prevent its unintended use. All returned material will be controlled via a material Non-Conformance Report (NCR) for tracking purposes.

1.C.3. CONTINUOUS REPLENISHMENT

The store replenishment process for spares is ensured throughout by reviewing the re-order level of spares and their consumption rate.

The Purchase & Stores officer and the Warranty Engineer will identify the necessity of materials and the quantity according to planned activities and will ensure the availability of those materials. In case materials are not available in store or near the re-order level the store will automatically request the required materials.

The continuous replenishment of the spares will be a process based on the re-order level and the minimum order level. The re-order levels will be estimated and updated regularly considering the consumption, delivery times and safety factors.

1.D. TECHNICAL INVESTIGATION

Technical investigations will be the responsibility of the Warranty Engineer. Where the system requiring investigation is supported via a support contract with an OEM, the Warranty Engineer will involve the OEM, as appropriate, to meet the report timescales as required by the contract. All such support contracts will require the OEMs to provide technical investigation to support the needs of the project.

On completion of the Technical Investigation CAF will produce a report which will include incident and root cause analysis.

CAF has an internet-based software tool for managing of technical investigations called SAT Forum, which works as follows:

- Warranty team uploads IGs (technical investigation description documents) to the forum and CAF Headquarters' Rail Services engineering team receives it and starts an in-depth analysis. These IGs have a standard format for all projects
- Rail Services designates a specific engineer to manage the project who creates a table with all open IGs and other issues and meets regularly with Workshop Manager for general reviews. Rail Service engineers visit the site regularly for review meetings and/or recollection of data and tests of prototype solutions. This engineer will be the main point of contact for all technical problems and will take part in review meetings as required
- The Forum provides visibility and tools to manage the technical investigations in all worldwide CAF's contracts
- Rail Services capabilities include mechanical drawings, electrical schematics and software applications, as well as maintenance audits
- Once the root cause of the Technical Incident and the action plan is clear, it is uploaded to the Forum and the IG is closed.

1.E. WARRANTY MANAGEMENT OPERATING SYSTEM (SOG)

CAF has been globally implementing a maintenance/warranty operating system in all projects for managing the maintenance/warranty activities.

This system is applicable once trains are fully in service and warranty works actually start. It is simply a methodology to manage the maintenance/warranty activities within a depot and standardize the way maintenance is managed, ultimately making the operation more efficient and cost-effective. The operating system flow diagram is made up of five basic elements Reinforced by a fundamental concept called "FEEDBACK".

Figure 6. Management Operating System process

The success of this system relies on the analysis of deviations from plan, schedule, and problems within a short time, thus enhancing maintenance opportunities. The data analyzed in the monitoring reports shows if the various objectives are being met so that corrective actions can be taken through the Operations Meetings, if necessary.

This daily, weekly and monthly meeting system carried out in a structured way and with content from the analysis of the operation of the system, ensures discussion of problems arising from deviations at each supervisory level, and increases formal communication.

The system enforces the development of a maintenance master plan, a monthly and weekly maintenance plan and finally a daily program for all the maintenance activities performed in Depot. Thus, the Maintenance Operating System for the maintenance area has the fundamental objective of providing information and establishing the decision making dynamic appropriate to the continuous improvement of the system's management.

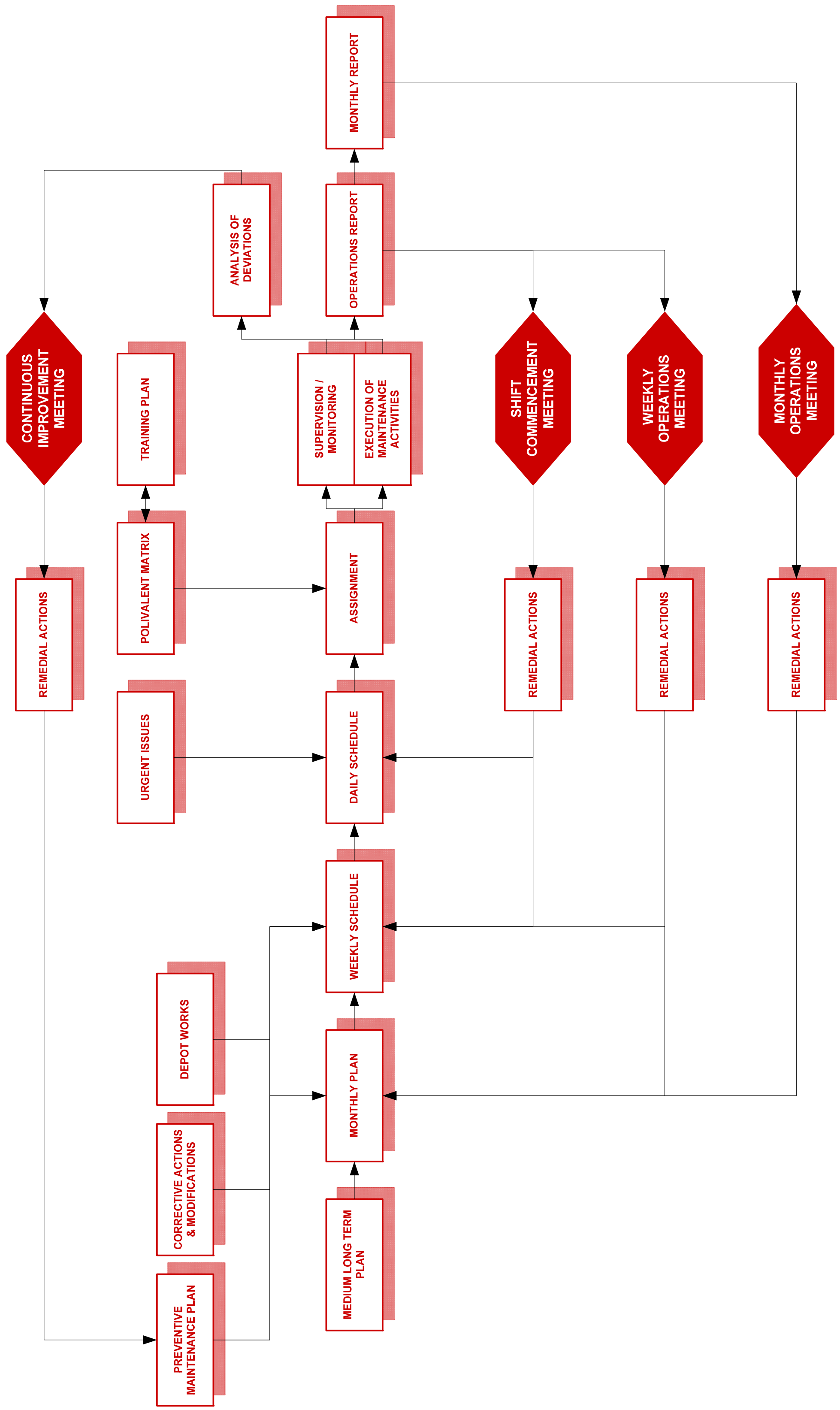

Figure 7. Warranty Management Operating System Process

1.F. COMPUTERIZED MANAGEMENT SYSTEM

CAF maintenance software (Infor EAM) is programmed by the IT department within the CAF Rail Services Group with relevant details for the project. It is simply a Computerized Maintenance Management System (CMMS) and it is considered the main tool of the Management Operating System mentioned in Section 1.E.

This software will be used on site to control

- Train configuration and modification status
- Material control, storage and returns
- Material purchasing
- Daily work programming
- Corrective maintenance activities
- Train kilometers accumulated, reliability and availability
- System/equipment reliability data

1.F.1. INFOR EAM

The Infor EAM system, operating under Windows®, has been chosen as the underlying system for maintenance management. It can be used for all aspects of scheduling warranty work, personnel, materials, failure management, documentation and reporting. The system is specifically designed for maintenance activities, particularly for reliability improvement, reducing costs and continuous improvement.

It will be possible to update it with information on work completed and time taken at out-based locations. It will also have the ability to generate work cards for warranty staff and provide updates for component serial numbers for stock control. CMMS also has powerful reporting tools which will support the provision of periodic reports as required under the contract.

Faults logged on CMMS system will be available for all relevant parties to review, and there will be a facility to highlight ‘new’ faults on the streetcars.

1.G. QUALITY MANAGEMENT

Warranty activities will be carried out as per the ISO 9001 Quality Assurance Standard and associated internal procedures, which are defined in CAF’s internal process named as CAFRS16.02, Execution of Warranty Services.

The above mentioned process guarantees that adequate Warranty Service organization and the resources are put in place to ensure that the vehicles will be able to operate at an optimum service level. This internal process can be made available upon Customer request.

1.H. WARRANTY PROGRESS REPORT

CAF will provide Warranty Progress Reports, to outline details of performance activities and results. The Warranty Service team will therefore be responsible for:

- Presenting the relevant progress reports
- Making available the results and records of every systems assurance task carried out
- Demonstrating the achievement of the RAM goals by means of the reports created for that purpose

CAF will agree with the Customer, the form in which the progress report will be presented and its content. The following information related to Services will be included in the monthly report:

- Fleet Status report including deferred work
- Unit failure report including root cause and status
- Fleet Configuration Report
- Warranty Claim Status
- Corrosion Assessments where applicable
- Fleet risks and issues

1.I. MINIMUM DEPOT REQUIREMENTS FOR WARRANTY ACTIVITIES

The depots where warranty activities will be carried out will need to be equipped with at least the following equipment:

- Suitable running maintenance tracks and facilities
- Suitable lifting track for the lift of the complete train
- An office for the use by CAF's warranty staff
- A warehouse for the storage of spare parts
- Common locker, toilet and canteen facilities for CAF's staff

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Sub-Part D – SYSTEM SUPPORT PLAN

Sub-Part D – System Support Plan

SECTION D QA PLANS, TRAINING MATERIALS, MANUALS AND CATALOGS

1.A. TRAINING

1.A.1. GENERAL

In order to organize the training courses, CAF works in cooperation with Geminys, a division of CAF which specializes in the development of vehicle documentation and operation training. Geminys has developed all of the documentation and training for all recent URBOS platform streetcar projects, taking into consideration the specific details of each streetcar and end customer.

CAF will provide a training program for a selected group of instructors, supervisors, mechanics, technicians, and train operators. The number of total attendees and groups may be reasonably changed during the later stages of project design and construction, to meet the needs of the customer. The objective of the training is to provide the attendees with a sufficient level of streetcar definition, functionality, and performance knowledge to operate and maintain the streetcars. The contents of the training will be based on the operating manual and the maintenance documentation delivered as part of the overall project documentation.

The training courses will typically consist of a combination of classroom lectures plus “hands on” visits to a streetcar in the maintenance facility (in working order, but static), to reinforce the theoretical concepts presented during the lectures. During training, there will be support from an engineer familiar with the project to respond to questions that may arise during the course. As an integral part of training, questionnaires will be prepared and administered to trainees to ascertain the level of knowledge acquired during the courses, and as a method to continuously improve the courses. The training documentation will be provided in the English language, and training will be conducted on the City’s premises.

1.A.1.1 TRAINING PROGRAM PLAN AND MATERIALS

CAF will submit a training program plan that will include the following items:

- A narrative description of the planned training for the City of Seattle’s personnel.
- A training schedule, including factory training.
- CAF’s approach to training the City’s instructors who will train City personnel.

- A description of the training experience for the staff responsible for preparing and implementing the training programs.
- An objective testing/evaluation system to report on the progress of each trainee during training. (CAF will not evaluate Seattle's personnel directly).

Please find attached the Cincinnati Training Schedule, Appendix D.D.1.

All training materials will be submitted for review and approval prior to the start of any training course. CAF will provide materials to support each course in the training program, including instructor guides, student guides, training aids, student workbooks, and operator/maintenance manuals.

1.A.2. MANUALS AND CATALOGS

1.A.2.1 MANUAL DEVELOPMENT AND DELIVERY

CAF has provided manual solutions in response to diverse customer requirements, in conjunction with its subsidiary Geminys. Geminys and CAF have a very close, long standing working relationship. Geminys is fully dedicated to designing and producing technical and interactive documentation, such as operating manuals, maintenance manuals, software manuals, training manuals, and catalogs; and integrate sub-supplier information to create a final product that satisfies the customer's requirements. CAF understands the importance of manuals in enabling operations and maintenance staff to achieve a high level of performance. The manuals for this project have largely already been developed for Cincinnati and Kansas City, but will be updated to reflect the vehicle design changes requested by City of Seattle. The Final Draft of the Manuals will be delivered prior to delivery of the first vehicle, with completed manuals delivered one year after first vehicle delivery.

1.A.2.2 TRANSFER OF ENGINEERING DESIGN TO MANUALS

The manual's development and review process will coincide with the design review process. Geminys was provided design review submittals as the design phase progressed. Additionally, once Geminys developed a draft of the manuals, the draft was submitted to the relevant CAF design engineer for review and comment, as part of an iterative process.

Official first drafts of the manuals were delivered to Cincinnati for review and comment. After incorporation of the authority's comments, Geminys and CAF continued the iterative review and comment process. The final drafts of the manuals were approved by CAF's engineering department before they were delivered to Cincinnati (SORTA). The design changes required by this project will be similarly incorporated. The manuals will also be updated to reflect the changes and lessons learned from the first period of maintenance.

1.A.2.3 TRUCK MAINTENANCE MANUAL

Please see Appendix D.D.2 Truck Maintenance Manual.

1.A.3. SPECIAL TOOLS AND TEST EQUIPMENT

Please refer to Appendix D.D.3, Spare Parts and Special Tools, which shows quantities recommended by CAF; for example for eight (8) streetcars in column B. Those quantities that differ from the RFP are highlighted in red. The Spare Parts list will be modified and adapted to the quantity of ordered vehicles once the contract is signed.

Quality Assurance

Please find attached an example of the Quality Assurance Plan of CAF (see Appendix D.D.4 Quality Assurance Plan). For further detailed information please refer to Section A Program Control and Quality Assurance of this Sub-part.

APPENDIX DD.1

Cincinnati Training Schedule

CINCINNATI TRAINING SCHEDULE

Week	Monday	Tuesday	Wednesday	Thursday	Friday
1		CAF	CAF	CAF	
2	MERAK	MERAK	MERAK/IFE	IFE	IFE
3	KNORR	KNORR	KNORR	DELLNER	DELLNER
4	HASLER	HASLER	CAF P&A	CAF P&A	CAF P&A
5	CAF P&A	CAF P&A	CAF P&A	SCHUNK	HOPPECKE
6	HUBNER	SEPSA	SEPSA	SEPSA	

SUMMARY

EEFAE	Days
CAF CARBODY	2
CAF TRUCK	1
KNORR	3
MERAK	2.5
IFE	2.5
CAF P&A TRACTION	3
CAF P&A COSMOS	3
SCHUNK	1
SEPSA PIS & CCTV	3
DELLNER	1.5
HASLER	1.5
HUBNER	1
HOPPECKE	1
TOTAL	26

APPENDIX DD.2

Truck Maintenance Manual

SECTION 9 - TRUCK

Paragraph Title Page No.

9.1 GENERAL DESCRIPTION

Modules C1 and C2 are supported by means of motor trucks. Both motor trucks have same characteristics.

These motor trucks have four motors which are joined two by two along their longitudinal axes and each one is solidly joined to the gear unit forming a single unit. The motor-gear unit hangs from the truck frame from a series of interspersed elastic rubber elements.

Each motor drives a gear unit that transmits the driving torque to the wheel axle through a toothed coupling. This enables movement caused by the travel of the primary suspension. An elastic star type coupling is mounted between the motor and the gear unit.

The primary suspension consists of rubber and steel bell type springs.

The secondary suspension consists of 4 cylindrical wire coil springs with elastic bump stops. Damping is done externally by hydraulic dampers in parallel with the springs, two in the case of the motor truck. The secondary suspension has a leveling system, one for each suspension spring, to compensate for the stroke of the secondary spring caused by passenger load differences, thereby reaching a defined door entry height with regard to the platform height.

The carbody is supported directly by the truck via secondary suspension springs and the vertical hydraulic dampers. The traction and braking forces are transmitted via traction rods.

The planned braking system consists of one disc per wheel. These are operated using reverse calipers. Furthermore, each truck has two electromagnetic brakes that are used in case of emergency.

The parking brake is also applied by means of reverse calipers. It is equipped with a pressure chamber and a secondary piston that allows the parking brake to be released from the cab through a secondary source of pressurized oil. There is also a manual mechanical device that acts directly on the brake calipers for quick and manual release.

Motor trucks.

No.	Description
1	Truck frame
2	Axle bridge
3	Primary suspension springs
4	Secondary suspension
5	Motorization
6	Brake assembly
7	Electromagnetic brake
8	Sanders and lifeguards
9	Wheel flange lubricators

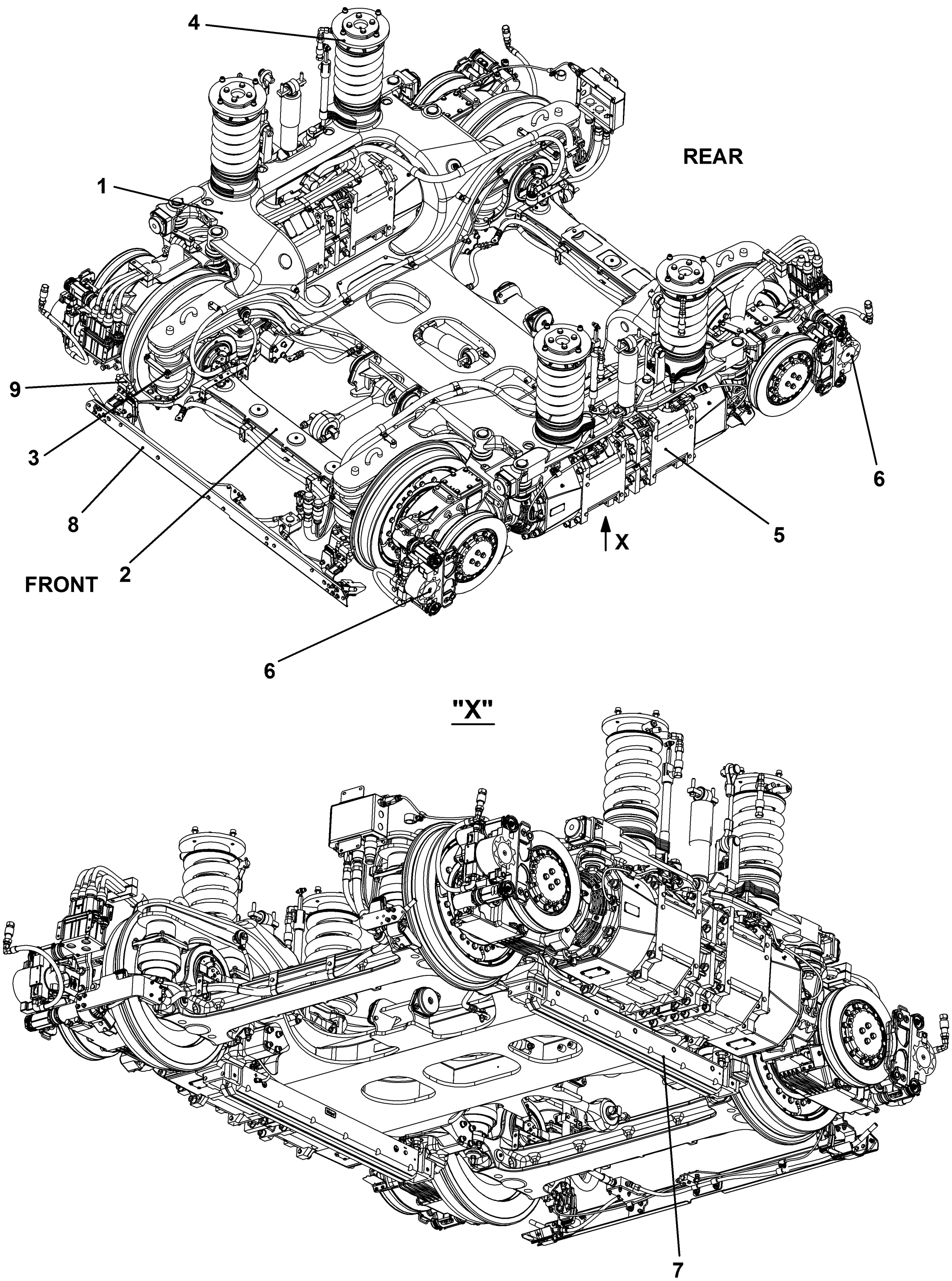


Figure 9-1. Motor truck assembly.

9.2 MAIN COMPONENTS

9.2.1 Truck Frame

The truck frame is a rigid structure representing the main structural part of the truck where the rest of the components are attached.

The truck frame is designed for a rational distribution of stress points, preventing stress concentration on joints between parts and in sharp changes of section.

The truck frame rests on the axle bridges through the primary suspension arrangement.

The structure of the truck frame is H shaped. It consists mainly of 2 longitudinal beams (1), joined by a crossbeam (2), and 2 consoles (3) at either end.

The structure of the longitudinal beams, crossbeam and consoles is similar. They basically consist of several webs, external or internal, a series of stiffeners and ribs acting on sections subjected to the largest efforts, and 2 plates, upper and lower, which act reinforcing the overall structure.

Suitable machined supports have been welded to the truck frame for the attachment of different components of the truck.

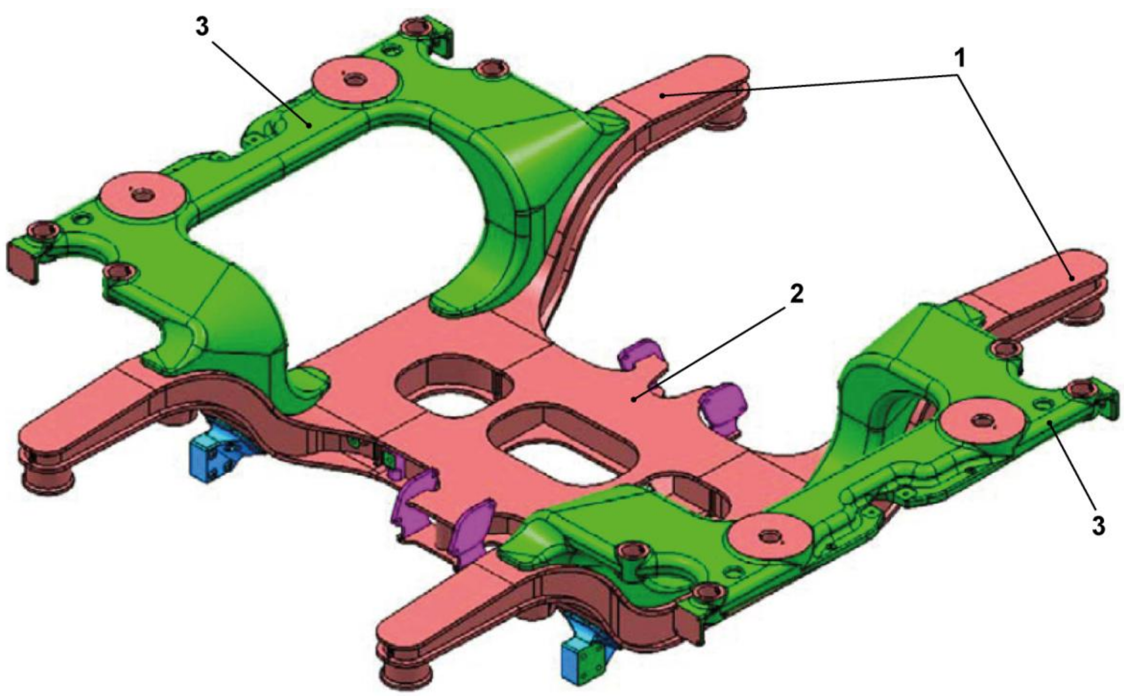


Figure 9-2. Motor truck frame.

9.2.2 Axle Bridge

The axle-box bridges are free wheel type and they consist of a casted double "T" beam and press-fitted cylindrical journals on the upper face of its ends. The wheels are mounted on the journals using bearings.

The axle bridge consists of a bridge frame (1) and 2 resilient wheels (2). The current return devices and the sensors are mounted on the axle-box bridges.

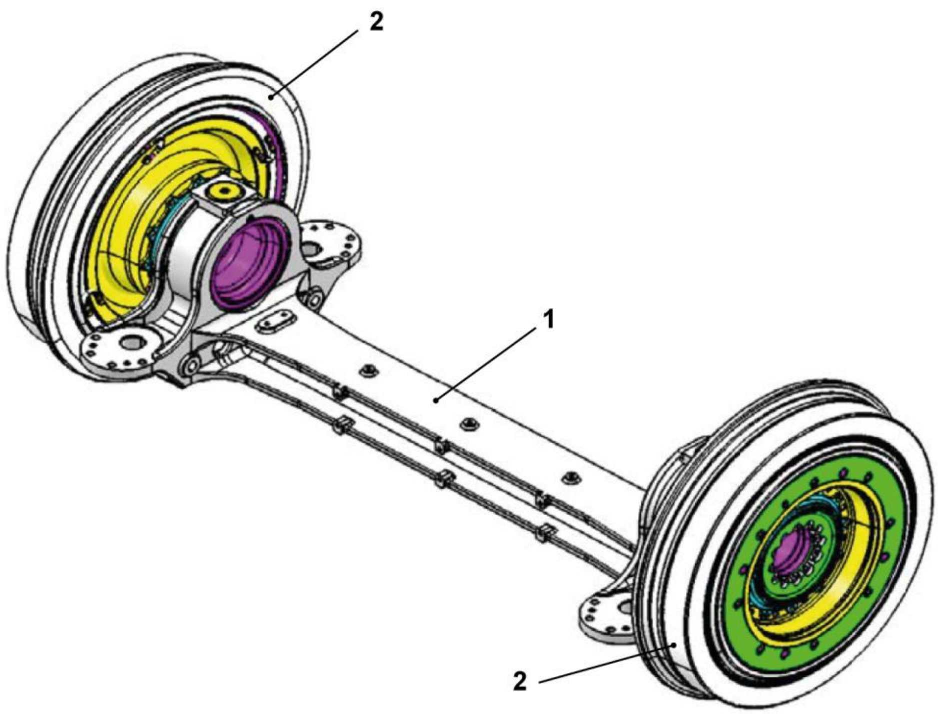


Figure 9-3. Axle bridge.

9.2.2.1 Axle Box

The axle box consists of a cast bridge frame (1) with 2 press-fitted journals (2) on each end.

Tapered bearings (3) are assembled onto these journals (2) to allow free movement of the wheels.

Moreover, the bridge frame has some supports where the primary suspension rests.

The bridge frame is provided with rubber stops (4) that prevent metal-to-metal contact in case of a failure in the primary suspension.

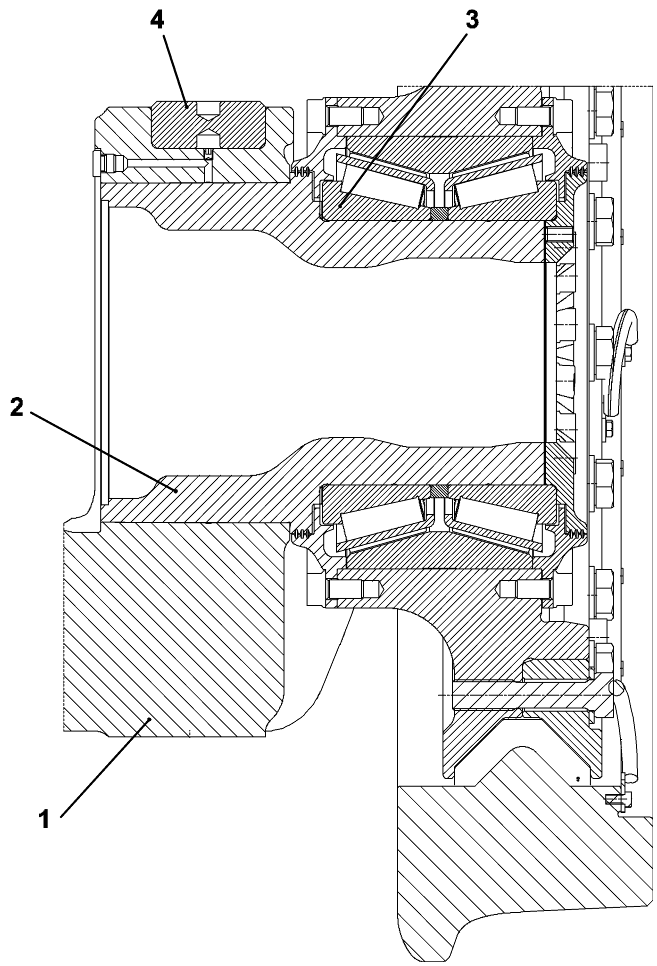


Figure 9-4. Axle box.

9.2.2.2 Resilient Wheels

Each resilient wheel consists of the following elements:

- Wheel body (1): This is the inner part of the wheel, which is in contact with the bearings.
- Wheel tire (2): This is the outer side of the wheel, in contact with the rail.
- Ring (3): This is bolted to the hub. It is used to replace the tire by removing the bolted connections.
- Rubber blocks (4): 23 “V-Type” rubber blocks are compressed between hub and tire. “V-Type” geometry assures high axial wheel stiffness and improves the streetcar’s dynamic behavior.
- Grounding braids (5): 4 external shunts are placed per wheel between hub and tire as the electrical interface that grounds the vehicle to the running rails to return propulsion and auxiliary current, and to shunt the signal system track circuits from rail-to-rail.

The rubber blocks (4) absorb the forces and vibrations caused by the resilient wheel in contact with the track. They also allow radial, tangential and axial movements of the solid tire (2) with respect to the wheel hub center (1).

The tire is treated to achieve greater resistance to wear and good adherence to the track.

The resilient wheel is equipped with 4 grounding braids (5) that electrically connect the wheel body (1) and the wheel tire (2).

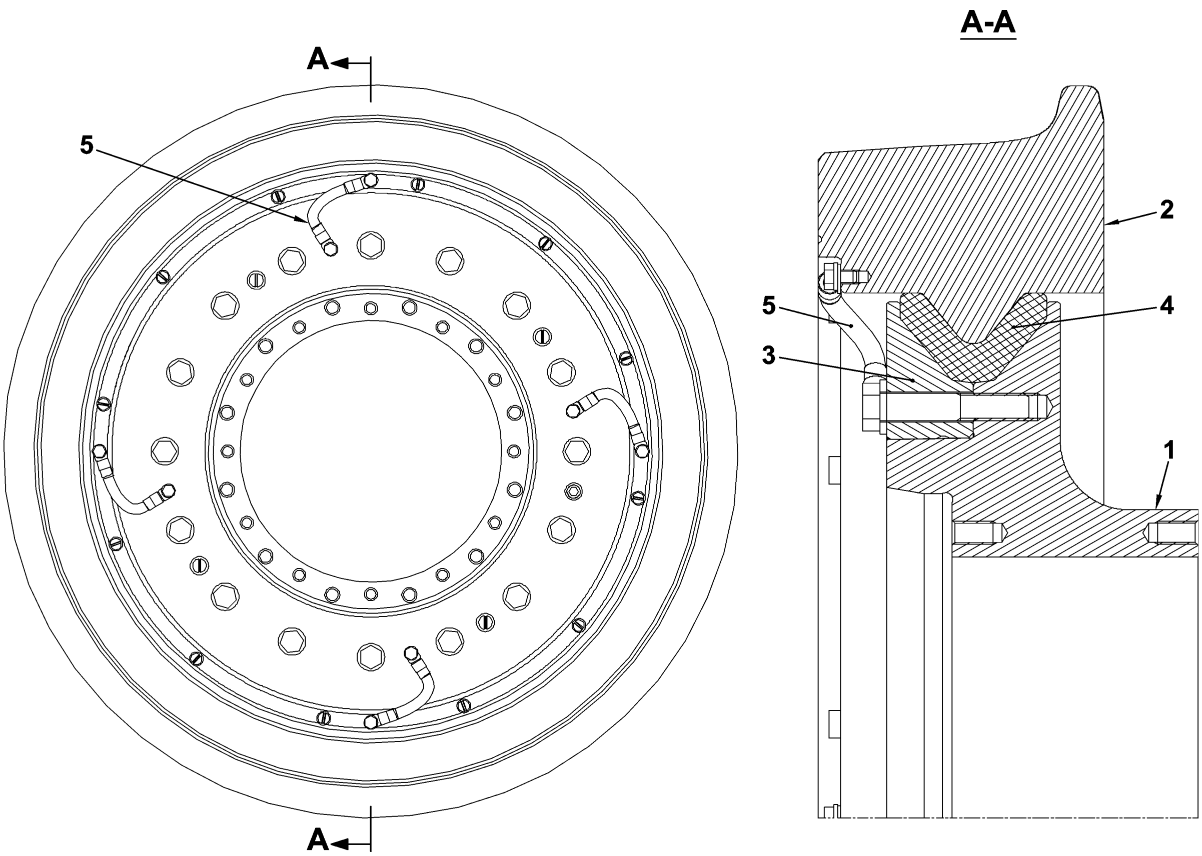


Figure 9-5. Resilient wheel.

9.2.2.3 Disc Brake and Speed Sensors Subassembly

The truck braking equipment consists of the following items:

- Brake discs.
- Hydraulic reverse type brake calipers and corresponding pads.
- Electromagnetic brakes.

A disc and a caliper is used for each wheel. The brake calipers on the motor trucks are attached to the gear unit housings.

The brake calipers are reverse type, so, if there is a loss of hydraulic fluid, the pads press on the discs and provide maximum braking. Therefore, the system operates with an intrinsic safety system. In normal operation, the disc type preloaded springs fitted in the brake caliper pistons are retained by the hydraulic pressure applied to these hydraulic pistons. During braking, the pressure in the circuit is reduced, so the force of the preloaded springs is applied partially.

The brake calipers are equipped with an automatic adjustment system for the clearance between the brake pads and disc. Therefore, the separation is maintained constant independently of the accumulated wear of both elements.

Furthermore, two electromagnetic brakes are fitted, one on each side, to act as emergency brakes. They provide additional braking capacity in case of emergency.

The electromagnetic brakes are suspended from two mountings attached to the arm of the axle-box bridges. They are suspended by means of coil springs with a mechanism to regulate the distance to the track rails.

The mountings are attached to the truck frame to absorb longitudinal and transversal braking forces occurring in these elements.

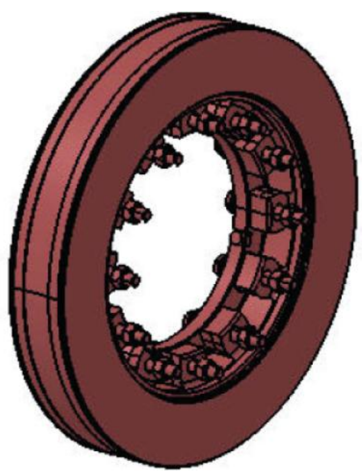


Figure 9-6. Brake disc.

9.2.3 Primary Suspension

The primary suspension connects the truck frame with the axle bridge. This suspension transmits both vertical and transversal forces caused by the traction and braking between the truck frame and the axle bridge.

The primary suspension consists of 8 rubber-steel springs (1) fitted between the axle bridge and the truck frame.

The stiffness of the primary suspension springs on the horizontal plane provides an adequate longitudinal and transversal union between axle boxes and truck frame. The chosen stiffness values allow stable running of the vehicle throughout the speed range up to maximum speed

and proper curve negotiation and low track aggression. It also allows vertical displacement of the primary suspension.

Its vertical stiffness has been studied to achieve suitable performance against vertical irregularities on the track, ensuring an even as possible load distribution between truck wheels and consequently taking optimal advantage of adherence, reducing the dynamic forces and accelerations due to track irregularities.

The lifting stop (3) limits the extension stroke of the suspension allowing the truck to be lifted with the axle bridges hanging.

The compression stop (2) is located on top of the axle bridge and is fitted with a rubber stop to prevent direct metal-to-metal contact.

The height regulation in case of excessive creep of the springs is achieved by placing shims between the springs and the axle bridge.

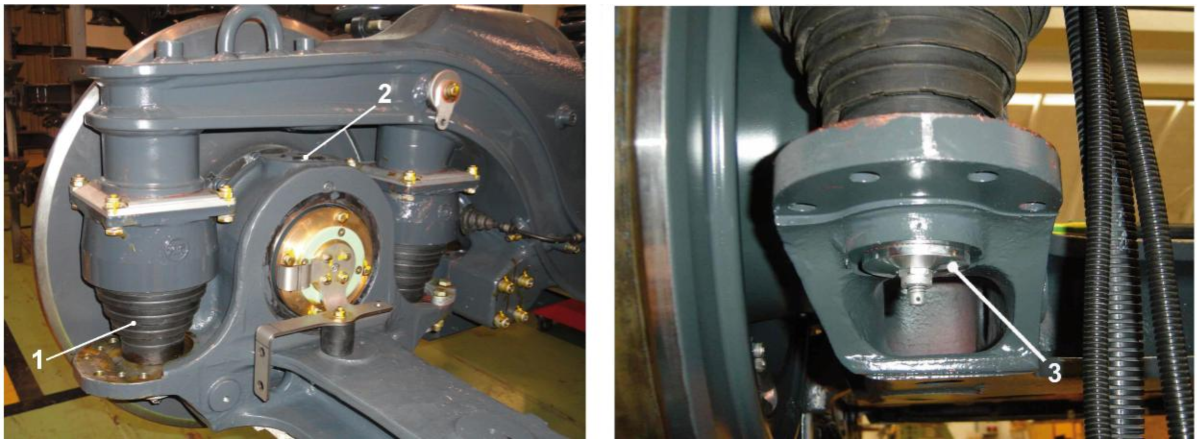


Figure 9-7. Primary suspension.

9.2.4 Secondary Suspension

The secondary suspension consists of a set of elastic elements, dampers and associated components connecting the frame to the car body. This suspension transmits and damps the static and dynamic forces.

The secondary suspension consists of 4 coil springs (1, Figure 9-8), mounted directly between the car body and truck frame, and vertical hydraulic shock absorbers (2), which have been fitted parallel to each other.

The transversal loads are transmitted through the secondary suspension springs (1), which are complemented at the end of their stroke by a series of progressive rubber lateral stops (3). Accordingly, a transversal hydraulic damper (4) has been fitted to reduce any suspension oscillations in this direction.

Vertical force at the end of the travel of the spring is reduced using progressive rubber elastic elements, making the suspension progressive and limiting the maximum stroke.

Besides, the truck is provided with 4 progressive rubber rotation stops (5) which limit the maximum rotation of the truck.

It also has a wheel wear compensation system that allows floor-to-rail height to remain constant. This consists of shims located under the secondary suspension springs.

The car body to truck frame connection is through a drag link (6) provided with maintenance-free rubber joints at their ends. The drag link transmits the traction and brake efforts between the car body and the truck.

There are two slings (9) connecting the truck to the car body to stop the leveling element from reaching a maximum level when the car body is being lifted.

9.2.5 Leveling Element

The height of the hydraulic component is automatically adjusted via a leveling valve to ensure that the height of the secondary suspension system remains constant.

This arrangement adjusts the height of the secondary suspension, which is measured by a linear sensor (8) placed in parallel with the coil spring. Height is maintained constant by injecting or removing hydraulic fluid from the hydraulic component.

The hydraulic components are also used to compensate for loss of floor height due to wheel wear.

The leveling element (7) consists of a cylinder housing for the main parts and a piston. The cylinder housing is a gray cast part with a conical shape, integrated into the secondary spring with an adapter ring. The piston is a nitrided steel part, equipped with a flange, which is mounted to the car body.

The purpose of the adapters is to connect the leveling element (7) with the hydraulic leveling system. An adapter is used to connect the element, depending on the truck side. The other adapter stays plugged.

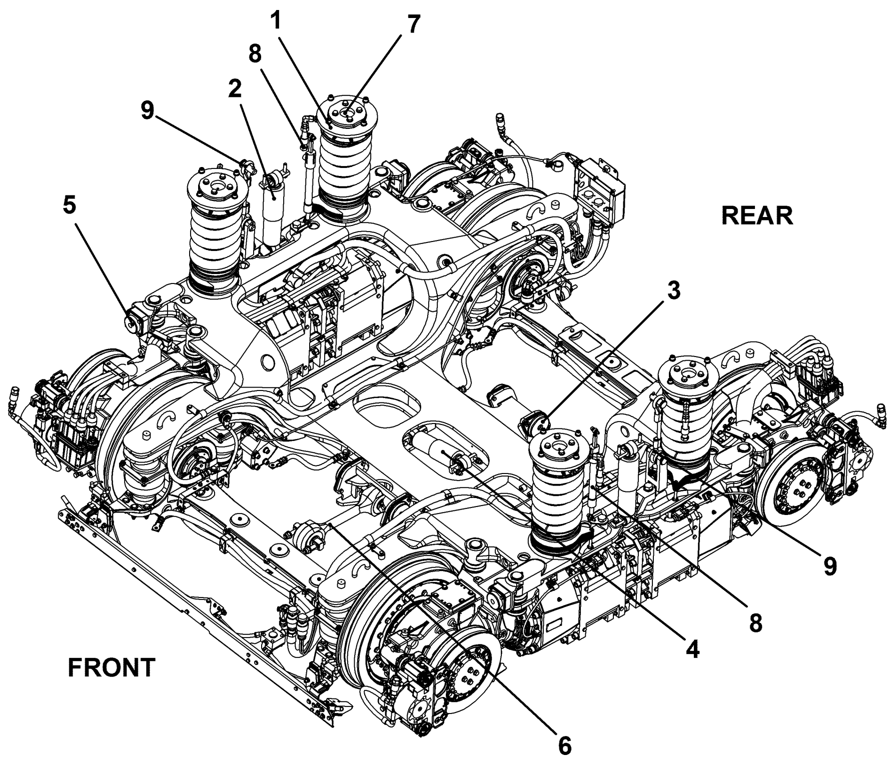


Figure 9-8. Secondary suspension.

9.2.6 Transmission

Trucks are equipped with two drive units. Each drive unit is composed of:

- 1 double traction motor (1).
- 1 gearbox, right side (2).
- 1 gearbox, left side (3).
- 2 motor-gearbox couplings.
- 2 gearbox-wheel couplings.

The torque developed by the 2 double traction motors is transmitted through the couplings and gearboxes to the wheels.

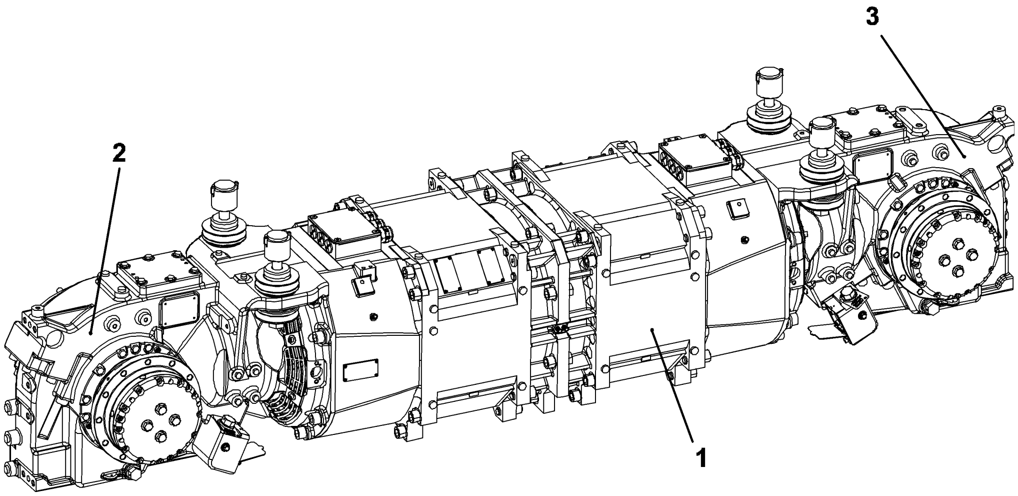


Figure 9-9. Drive unit arrangement.

9.2.6.1 Gearbox

The gearbox is a 1-stage reduction gear, bevel gearbox type and fully suspended on the truck. At the input side, the motor is mounted onto the gearbox via a coupling. The output is connected directly to the wheels by a toothed coupling (1).

The gearbox is mounted onto the trucks by means of 2 suspension points for elastic elements. Thus, the double traction motor is fully suspended between both gearboxes.

The gearbox output is connected directly to the wheels by the gearbox-wheel coupling (2). This coupling is able to accommodate the movements of the wheel relative to the gearbox.

The gearbox of the left side and the gearbox of the right side are symmetrically equal and they have the same parts, except the housing assembly (3), the bevel gear pinion (5), the bevel gear gearwheel (6), the inspection cover (7) and grids (8 and 9).

The gearbox consists of a pinion (5) and gearwheel (6). Both are Klingelnberg type bevel gears. The gear profile is optimized to reduce the noise.

The material used in the manufacture of all the gears is a high-quality hardened steel alloy as per ISO 6336-5. After machining and heat treatment, the gear is ground for maximum running smoothness and durability.

The gearwheel (6) is fixed to the output shaft (12) by 20 screws (23).

The housing assembly (3) of the gearbox consists of two half-shells (10 and 11) and it is made of nodular cast iron with a compact design that provides rigidity against deformation. The split plane goes through the center of the gearwheel (6). The 2 halves are fastened together and the interface is sealed.

The output shaft (12) is based on the housing assembly (3) by two tapered roller bearings (13 and 14).

The pinion (5) is mounted in the upper half-shell (11) by a set of bearings composed of a cylindrical roller bearing (15) and 2 tapered roller bearings (16). The outer race of the cylindrical roller bearing (15) is installed in the upper half-shell (11). The outer races of the tapered roller bearings (16) are installed in separate bearing carrier bushings (17 and 18).

The inspection cover (7) on the upper half-shell (11), allows inspection of the contact pattern of the hooks.

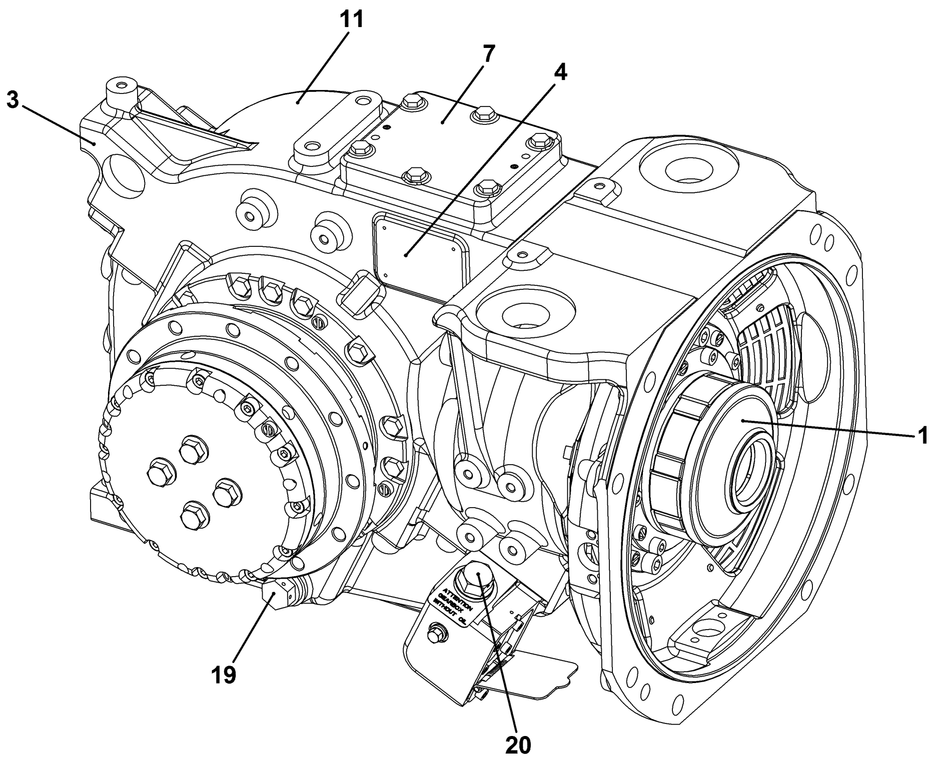
Thickness rings ensure good installation and adjustment of the bearings (13, 14, 15 and 16) play and pinion (5) and gearwheel (6) contact pattern.

The pinion (5), the bearings (13, 14, 15 and 16) and gearwheel (6) are oil-lubricated. During service, oil is collected in small cavities in the housing and delivered by channels to the bearings for greasing purposes. Ferrous abrasive particles are collected at the magnetic oil plug (19) in the lower half-shell (10). The oil level can be checked by the oil level device (20).

The seals between the pinion (5) and the gearbox housing (3) are contactless labyrinth seals. The output labyrinth seals have a V-ring (21 and 22) to protect against oil loss at low speeds. They are also designed to prevent entry of dirt or other contamination and to retain the oil.

The gearbox has attachment points for the brake caliper that is mounted on the gearbox by means of an adapter, while the brake disc is mounted on an output coupling adapter flange (24).

The gearbox housing has a nameplate (4) indicating the serial number, reference and other relevant information.



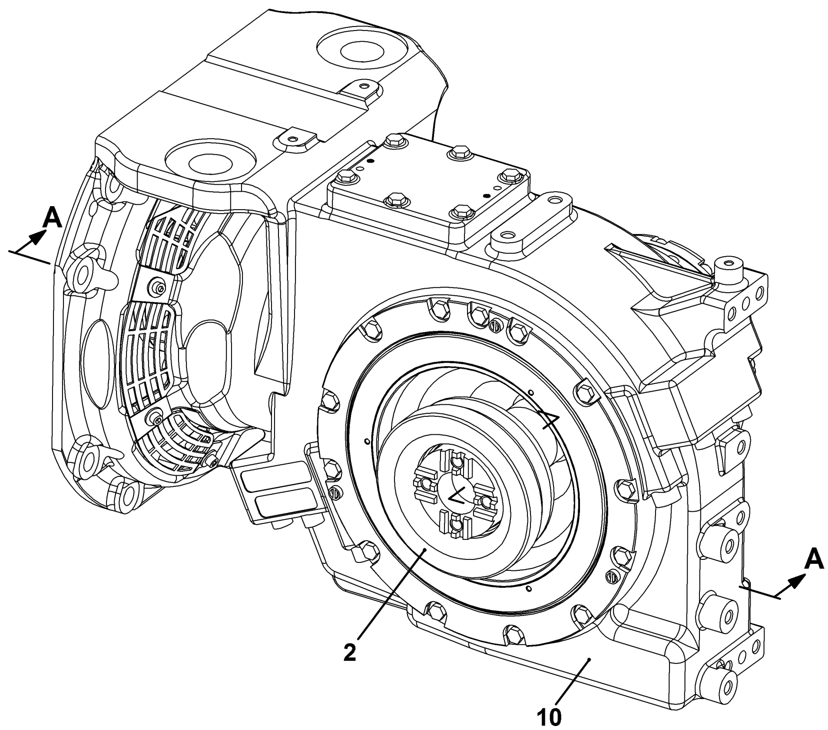


Figure 9-10. Gearbox (1/2).

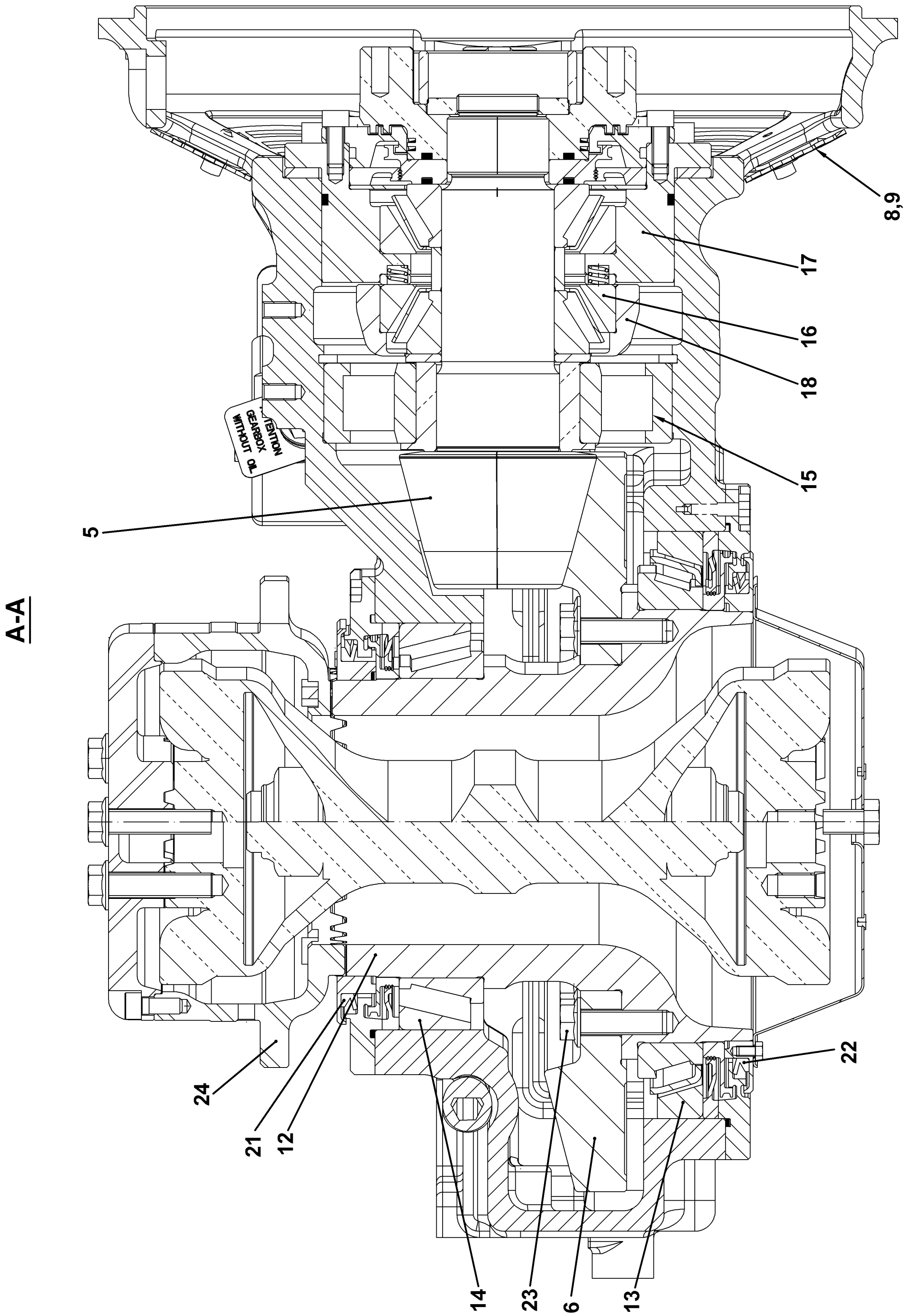


Figure 9-11. Gearbox (2/2).

9.2.6.2 Motor-Gearbox Coupling

The motor-gearbox coupling (1) is a flexible, maintenance-free element. The torque produced by the motor is transmitted through the coupling cam and the star (2) inserted between them. It is also able to accommodate any misalignment between the motor and the gearbox.

The motor-gearbox coupling is composed of:

- Semi-coupling of the motor side (3): This is fixed directly to the shaft of the motor. It is also equipped with threaded plugs (4) protecting the oil supply ducts for the processes of fretwork.
- Semi-coupling of the gearbox side (5): This is fixed to the bevel gear pinion (7) of the gearbox by means of a special nut (6).
- Star (2): Toothed part between both semi-couplings (3 and 5).

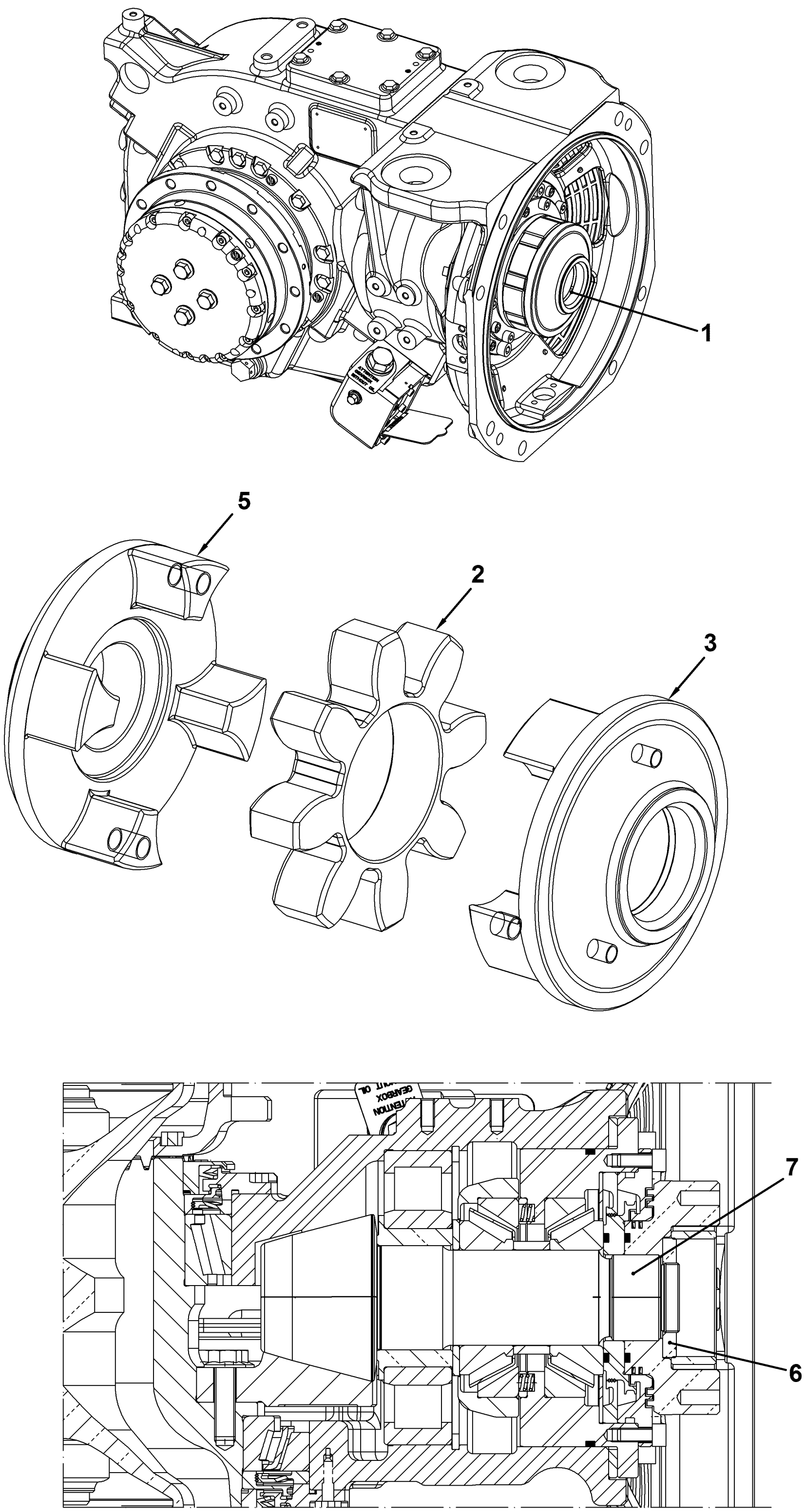


Figure 9-12. Motor-gearbox coupling (1/2).

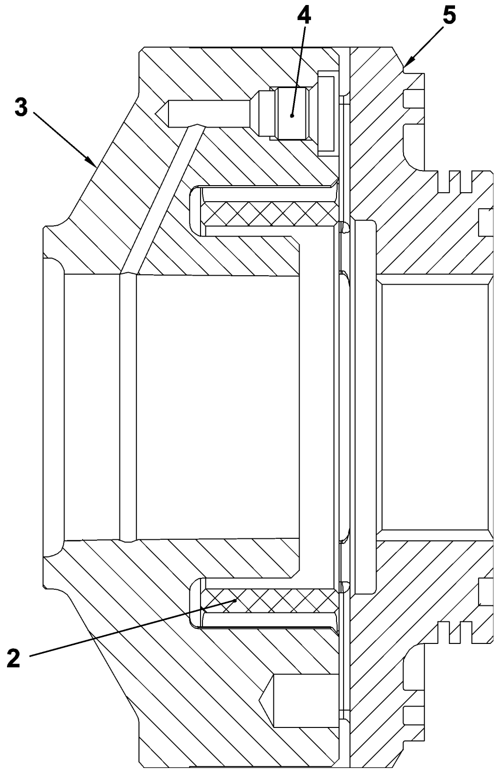


Figure 9-13. Motor-gearbox coupling (2/2).

9.2.6.3 Gearbox-Wheel Coupling

The toothed coupling is a gear-free rigid, self-centering and toothed coupling. It transmits the torque of the gearbox output by kinematic connection of crowns of interior and exterior teeth.

The gearbox-wheel coupling is basically composed of 2 sleeves (1) joined at the ends by a screw (2), a nut (3) and 2 spherical washers (6). The hubs (4), discs (7) and covers (5) are fixed at the opposite ends.

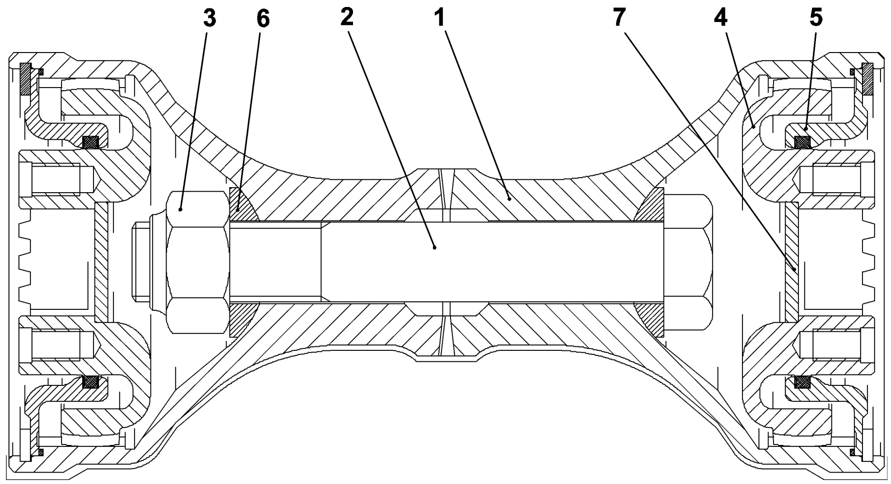


Figure 9-14. Gearbox-wheel coupling.

9.2.7 Electrical Installation

The motor power supply cables are attached to the truck frame by insulated cable clamps and are connected to the cables from the car body in junction boxes placed close to the trucks, to facilitate the connection/disconnection.

Connections to the auxiliary equipment on the trucks, speed sensors and electromagnetic brakes, are via flexible hoses attached to the truck frame by clamps. The car body is connected to the truck via connectors mounted in an accessible location. These connectors are waterproof and suitable for outdoor use.

9.2.7.1 Speed Sensors

The truck is equipped with 4 simple speed sensors (1) used to measure the speed of the traction motors, and therefore, the vehicle speed.

The trucks of C1 and C2 modules are also equipped with a speed sensor (2) used to measure the speed of the traction motors and transmit the speed to the event recorder.

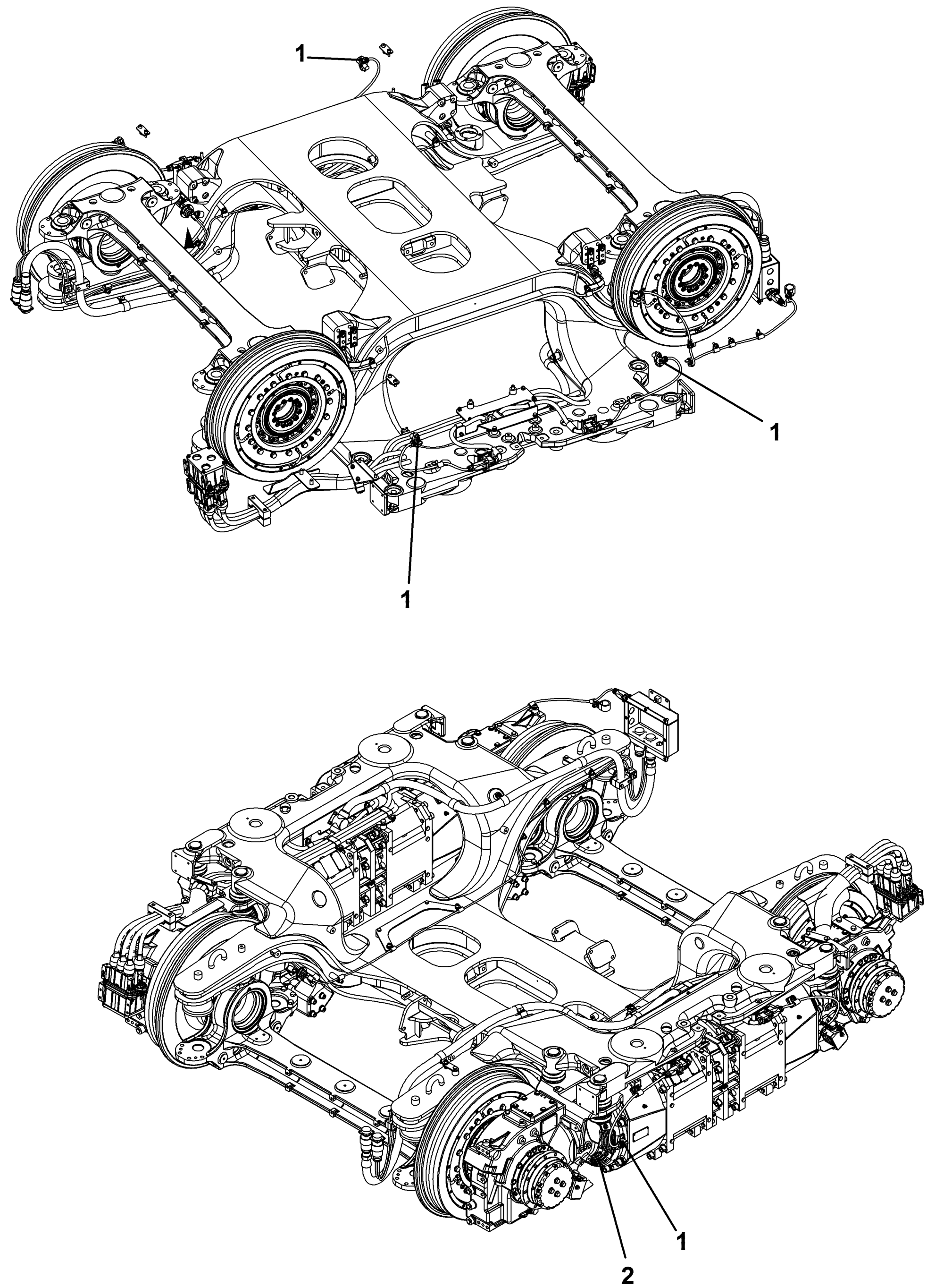


Figure 9-15. Speed sensors arrangement.

9.2.8 Ground and Current Return Installation

The trucks are fitted with 2 current return devices (1) mounted on the axle box bridges with adapters. Their mission, as the name suggests, is to return the remaining power to the current drive to the lane without crossing these bearings.

In addition, the truck is provided with 2 grounding devices (2) that protect personnel and passengers from high voltage derivations and maintain truck structure to ground potential. In case of an electrical short, this circuit will channel these currents.

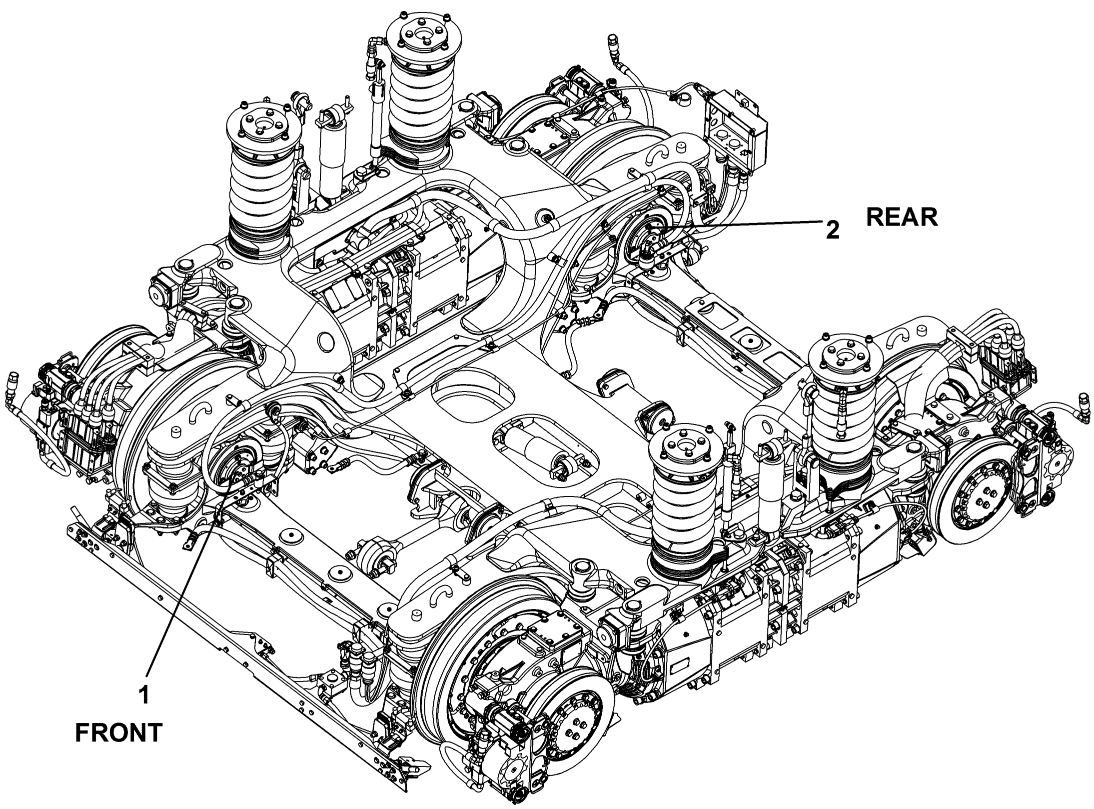


Figure 9-16. Ground and current return devices.

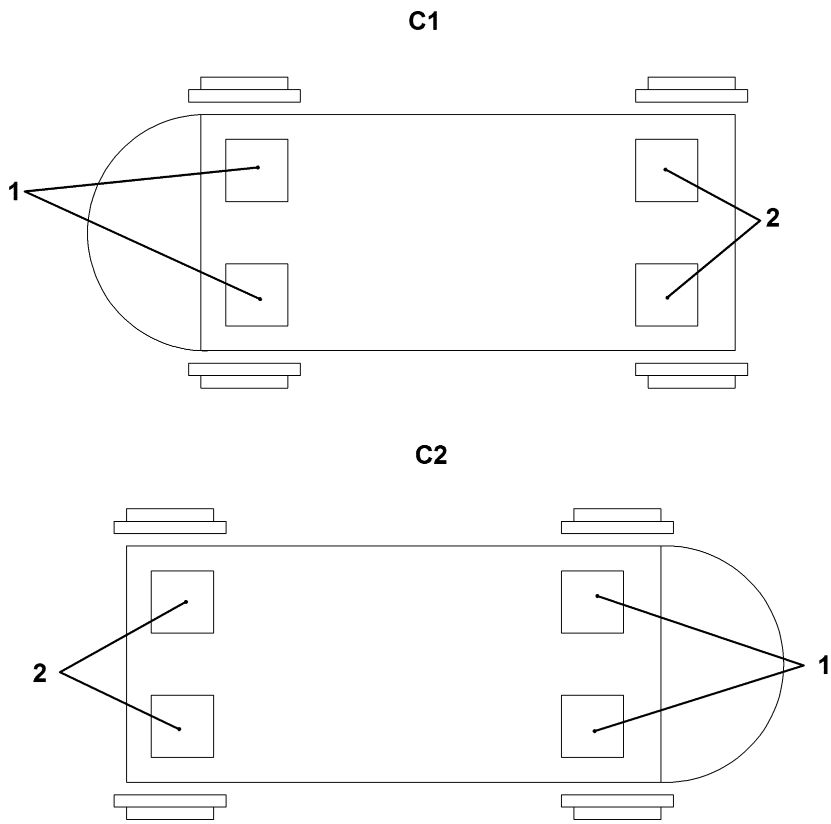


Figure 9-17. Ground and current return device schematics.

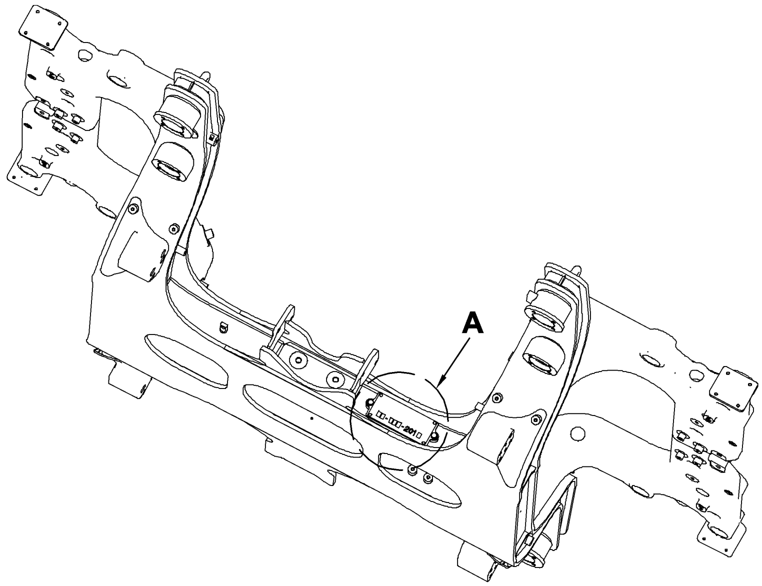
9.2.9 Other Equipment

Each truck has a 4-wheel sander system to improve wheel-track adherence, if necessary.

Flange greasing systems are mounted at the front axle bridge of the trucks, 2 in each wheel. This system sprays a small amount of grease over the flange. The nipple in the truck can be adjusted according to wheel wear. A rail greasing system is also mounted in each wheel. This system sprays a small amount of grease over the rail.

Additionally, a lifeguard is mounted at the front end of the trucks to remove stones or other small foreign objects from the tracks.

Each truck has a nameplate fixed to the truck frame. The truck numbering is shown in the table below.



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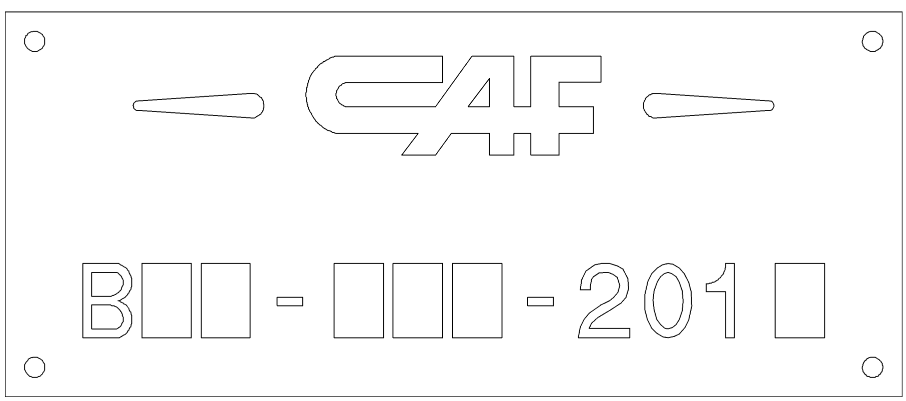

Figure 9-18. Nameplate.

Truck numbering.

Motor truck numbering (M.H1.00.001)
BM1-001
BM1-002
BM1-003
BM1-004
BM1-005

Motor truck numbering (M.H1.00.001)
BM1-006
BM1-007
BM1-008
BM1-009
BM1-010
BM1-011
BM1-012

9.3 TECHNICAL CHARACTERISTICS

9.3.1 General

• Distance between axles	70.87 in (1800 mm)
• Distance between springs at different fixing points	40.75 in (2070 mm)
• Primary suspension	Steel-rubber bell type springs
• Secondary suspension	Coil springs
• Drive unit:	
– Number of motors per truck	4
– Arrangement of motors	Longitudinal
– Gearbox mounting	Completely suspended
• Hydraulic brake system:	
– Type of brake	Discs
– Number of discs per truck	4
– Brake disc diameter	14.95 in (380 mm)
– Brake cylinders per truck	4
• Electromagnetic brake system:	
– Number of electromagnetic rail runners per truck	2
• Nominal maximum speed	43.5 mph (70 km/h)
• Wheel:	
– Type	Independent
– Maximum/minimum diameter	23.23/20.08 in (590/510 mm)

• Weight	11195 lbs (5043 kg)

9.3.2 Truck Frame

• Weight	1874.1 lbs (844.2 kg)
• Material:	
– Truck frame	Steel plates, S355 NL according to EN 10025-3
– Supports	Cast, E300-520 MSC1 UIC 840-2

9.3.3 Axle Bridge

• Weight	1215.8 lbs (547.7 kg)
• Axle box:	
– Weight	466.86 lbs (210.4 kg)
– Frame unit:	
o Material	GS25CrMo4 VII according to DIN 17205
o Weight	352.76 lbs (160.5 kg)
– Tapered bearing:	
o Dimensions:	
Inner diameter	5.5 ~ 5.501 in (139.7 ~ 139.725 mm)
Diameter of stub-axle	139.7 h6
Outer diameter	8.998 ~ 8.999 in (228.549 ~ 228.575 mm)
Width of outer race	3.865 ~ 3.877 in (98.171 ~ 98.476 mm)
Width between inner races	4.8671 ~ 4.8829 in (123.625 ~ 124.025 mm)
o Axial clearance:	
Before assembly	0.015 ~ 0.017 in (0.381 ~ 0.432 mm)
Theoretical clearance after assembly	0.0039 ~ 0.0138 in (0.100 ~ 0.350 mm)
o Grease	Shell Gadus Rail S3
o Weight	42 lbs (18.5 kg)
• Resilient wheel:	
– Tread diameter (new)	23.23 ± 0.02 in (590 ± 5 mm)
– Tread diameter (worn)	20.08 in (510 mm)
– Distance between the inner surfaces of the wheels	54.17 ± 0.08 in (1376 ± 2 mm)

– Difference between the tread diameters:

o New wheels:	
On the same axle bridge	≤0.01 in (0.3 mm)
On the same truck	≤0.02 in (0.5 mm)
o In service:	
On the same axle bridge	≤0.08 in (2 mm)
On the same truck	≤0.16 in (4 mm)
– Weight	374.51 lbs (168.7 kg)

9.3.4 Primary Suspension

- Primary spring:

– Material	Rubber M3 according to ISO 3302-1 standard
– Free height	7.79 in (198 mm)
– Height under tare	6.89 in (175 mm)
– Weight	17.160 lbs (7.73 kg)
• Compression stop:	
– Material	Rubber

9.3.5 Secondary Suspension

9.3.5.1 Spring Assembly

- Spring:

– Material	Steel, 46 SICRM06 according to EN 10089
– External diameter	8.11 in (206.2 mm)
– Free height	13.08 in (332.3 mm)
– Height of spring under load (30193 N)	11.61 in (295 mm)
– Diameter of wire	1.46 ± 0.006 in (37.1 ± 0.15 mm)
– Total number of coils	6.25
– Number of useful coils	4.75
– Average diameter of spring	6.65 ± 0.006 in (169.1 ± 1.5 mm)
– Direction of winding	To the right
– Stiffness (K)	810 N/mm ± 2.6% according to EN 13298
– Weight	54.456 lbs (24.53 kg)

- Elastic base:

– Material	Natural rubber, resistant to water, salts, grease and oil
– Height under 23500 N load	1.26 ± 0.009 in (32 ± 0.25 mm)
– Weight	10.87 lbs (4.93 kg)

- Vertical stop:

– Material	Natural rubber
– Maximum load	26487 N
– Weight	1.87 lbs (0.849 kg)

9.3.5.2 Lateral Stop

• Material	Cellular polyurethane, density 0.55
• Free height	0.79 in (20 mm)
• Weight	1.19 lbs (0.540 kg)

9.3.5.3 Rotation Stop

• Material	Rubber natural Shore 80 A
• Metal	Electrolytic coating according to EN 12329 Fe//Zn12//C
• Weight	1.19 lbs (0.540 kg)

9.3.5.4 Drag Link

• Material	Steel, C35E+N EN 10083-1
• Length between fastenings	14.37 ± 0.01 in (365 ± 0.25 mm)
• Weight	26.51 lbs (13.85 kg)

9.3.5.4.1 ELASTIC JOINT

- Rigidity:

– Radial	20000 ± 10% N/mm
– Axial	1730 ± 10% N/mm
– Torsion	350 ± 15% N/º
– Tapered	53 ± 15% N/º
• Service conditions:	
– Normal maximum radial force	12595 N
– Exceptional maximum radial force	364000 N

– Maximum normal torsion force	±6º
– Exceptional torsion force angle	±9º
– Normal maximum taper angle	±4º 30’
– Exceptional maximum taper angle	±6º 30’

- Resistant to water, salts, grease and oil.

9.3.5.5 Dampers

- Vertical dampers:

– Type	97V-1542
– Stroke	4.96 in (126 mm)
– Max. static load in extension	30 kN
– Attachment	Elastic joint
o Angular rotation:	
Cardanic	10º
Torsion	10º
o Stiffness (minimum value)	>12 kN/mm
– Nominal damping force	8500 N ± 15%
– Maximum damping force	15000 N
– Nominal velocity	0.1 m/s
– Maximum speed	1 m/s
– Weight	14.3 lbs (6.45 kg)

- Transversal damper:

– Type	97H-1324
– Attachment	Elastic joint
o Angular rotation:	
Cardanic	12º
Torsion	19º
o Stiffness	>12 kN/mm
– Nominal force	8000 N ± 15%
– Maximum damping force	15000 N
– Nominal velocity	0.1 m/s
– Maximum speed	1 m/s
– Weight	12.65 lbs (5.7 kg)

9.3.5.6 Leveling Element

• Hydraulic fluid	MIL – PRF -83283 (ROYCO 782 or equivalent)
• Maximum hydraulic pressure	155 bar (2,248 psi) 170 bar (2,466 psi) admissible in case of failure
• Piston diameter	70 mm (2.76 in)
• Ambient temperature range	-20ºC to +55ºC (-4ºF to +131ºF)
• Mounting hardware	Protected from galvanic corrosion with Molykote DX
• Bleed valve	Minimess 1620
• Locking bolt	30º (counter-clockwise)
• Fully retracted height	255 ± 1 mm (10.04 ± 0.04 in)
• Fully extended height	335 ± 1 mm (13.19 ± 0.04 in)
• Nominal length	260 ± 1 mm (10.24 ± 0.04 in)

9.3.6 Gearbox and Coupling

9.3.6.1 Gearbox

• Type	Hypoid bevel
• Total gear ratio	5.44
• Vertical off-set	1.18 in (30 mm)
• Maximum accelerating torque	600 Nm
• Maximum brake torque	650 Nm
• Maximum speed	4600 r.p.m.
• Greasing:	
– Oil type	MOBIL SYNTHETIC GEAR OIL 75W-90
– Initial oil volume	0.45 gal lqd (1.7 l)
• Weight	432.12 ± 2% lbs (196.6 ± 2% kg)
• Rated power	70 kW
• Paintwork:	
– Paint layer thickness	0.005 in (0.12 mm)
– Color	RAL 7016
• Working temperature	-25ºC/45ºC
• Mechanical short-circuit	2920 Nm

9.3.6.2 Motor-Gearbox Coupling

• Type	Rotex 65 (KTR)
• Rated torque	1645 Nm
• Maximum torque	3290 Nm
• Short circuit torque	3000 Nm
• Maximum speed	4600 r.p.m.
• Permissible misalignments:	
– Maximum axial misalignment	0.016 in (0.400 mm)
– Maximum radial misalignment	0.008 in (0.200 mm)
– Maximum angular misalignment	0º 10'
• Weight	9.48 lbs ± 2% lbs (4.3 ± 2% kg)

9.3.6.3 Gearbox-Wheel Coupling

• Maximum accelerating torque	3300 Nm
• Maximum brake torque	4590 Nm
• Short circuit torque	12566 Nm
• Maximum speed	836 r.p.m.
• Permissible misalignments:	
– Maximum axial misalignment	±0.16 in (±4 mm)
– Maximum radial misalignment	±0.98 in (±25 mm)
– Maximum axial misalignment	±0.12 in (±3 mm)
– Maximum radial misalignment	±0.49 in (±12.5 mm)
• Greasing:	
– Lubricant type	Texaco coupling grease
– Quantity per semi-coupling	0.19 lbs (90 g)
• Weight	39.68 ± 4.41 lbs (18 ± 2 kg)
• Paintwork:	
– Primer layer	Bicomponent 30 µm
– Color	RAL 7016 anthracite gray 60 µm

APPENDIX DD.3

Spare Parts and Special Tools

	Item No.	Qty	Qty (Recommended by CAF)	Unit	Description
SPARE PARTS					
A - Carbody					
A	1	1	1	Each	Articulation diaphragm or bellow assembly
A	2	1	1	Car Set	Articulation removable exterior sheathing, mounting devices and hardware
A	3	1	1	Car Set	Articulation Interior shrouding over bellows
A	4	1	1	Each	Articulation interior turntable floor hatches
A	5	1	1	Each	Articulation mechanical joint assembly, upper, complete
A	6	1	1	Each	Articulation mechanical joint assembly, lower, complete
A	7	1	1	Car Set	Articulation dampers
A	8	2	2	Each	Front end Obstacle Deflector assembly (as applicable)
B - Coupling System					
B	1	1	1	Each	Coupler and Draft Gear assembly, complete
C - Operators Cab					
C	1	2	1	Each	Master Controller, complete
C	2	1	1	Each	Operator's console panel(s), complete, excluding master controller, transfer switch and reverse switch, communications control head, but including wiring harness, all audible and visual indicators, pushbuttons and miscellaneous switches.
C	3	2	1	Car Set	All cab switches (except transfer and reverser switches), foot switches, pushbuttons, displays, meters, gauges, indicating lamps, LED's, lenses, and audible alarms.
C	4	1	1	Each	Transfer switch assembly (as applicable)
C	5	1	1	Each	Reverser switch assembly (in addition to switch supplied as part of master controller complete)
C	6	2	2	Each	Wiper motor
C	7	10	10	Each	Wiper motor arm
C	8	5	5	Car Set	Wiper blades
C	9	1	1	Each	Windshield washer pump
C	10	10	10	Each	Windshield washer spray nozzle
C	11	1	1	Each	Speedometer (in addition to the speedometer included in Line C2 as part of complete assemblies)
C	12	2	1	Each	Horn assembly (indicate if combined with bell assembly)
C	13	2	1	Each	Bell assembly (indicate if combined with horn assembly)

SPARE PARTS					
	Item No.	**Qty**	**Qty (Recommended by CAF)**	**Unit**	**Description**
D - Passenger Doors					
D	1	2	1	Each size	Door panel (RH), complete and ready to install, including window, seals, sensitive edges, and interior and exterior pushbutton switches
D	2	2	1	Each size	Door panel (LH), complete and ready to install, including window, seals, sensitive edges, and interior and exterior pushbutton switches
D	3	1	1	Car Set	Door controller module
D	4	1	1	Car Set	Door operator linkages and mechanism, complete
	5	1	1	Car Set	Door lower anchor with guide arms
D	6	1	1	Car Set	Door panel weather seals, except sensitive edges.
D	7	2	2	Each	Crew switch (interior/exterior)
D	8	1	1	Each	Internal door manual release (emergency egress) mechanism, complete with cable
D	9	5	5	Each	Door release replacement cables
D	10	1	1	Each	External door manual release (emergency egress) mechanism, complete with cable
D	11	1	1	Car Set	Passenger door control pushbutton switches (interior and exterior)
D	12	2	1	Each	Audible door closing warning indicator
D	13	1	1	Each	Door Out-of-Service indicator
D	14	1	1	Each	Visual door closing warning indicator
D	15	1	1	Each	Transom door open indicating light
D	16	2	2	Car Set	Door threshold extension
E - Heating, Ventilation and Air Conditioning					
E	1	1	1	Car Set	All heating elements (Overhead and floor)
E	2	1	1	Car Set	Air flow switches (all)
E	3	1	1	Car Set	Thermostats and temperature sensors (all)
E	4	1	1	Car Set	Temperature control relays (all)
E	5	1	1	Car Set	Heating / ventilation contactors (all)
E	6	1	1	Each	Air conditioning unit, complete
E	7	1	1	Car Set	Fusible links and plugs (all)
E	8	2	2	Each	Compressors
E	9	2	2	Each	Condenser fan motors
E	10	2	2	Each	Evaporator fan motors
E	11	5	5	Each	Crankcase heaters
E	12	10	10	Each	Service valve caps
E	13	1	1	Car Set	Resilient vibration isolation mounts (all)
E	14	10	10	Car Set	Fresh air and return air filters
E	15	1	1	Car Set	Operator's heater and window defrosting system, including controls, excluding cab windshield
D	16	1	1	Set	Set of control cards (complete), or microprocessor module (as applicable), for one HVAC unit

SPARE PARTS					
	Item No.	**Qty**	**Qty (Recommended by CAF)**	**Unit**	**Description**
F - Lighting					
F	1	1	1	Car Set	Fixtures for all interior and exterior lights and indicators (except cab console mounted items and door indicators
F	2	2	2	Car Set	All lamps, excluding headlamps
F	3	10	10	Each	Headlamp, exclusive of fixture
F	4	5	5	Each	Railroad headlight, exclusive of fixture
G - General Electrical					
G	1	2	1	Each	Pantograph assembly, complete
G	2	2	1	Each	Pantograph head, complete with suspension devices
G	3	10	10	Car Set	Pantograph shoe carbon insert set
G	4	1	1	Each	Pantograph mounting insulators
G	5	1	1	Each	Pantograph raise / lower actuator assembly, complete, including limit switches
G	6	1	1	Each	Lightning arrestor
G	7	1	1	Car Set	High Speed Circuit Breaker(s), complete
G	8	1	1	Car Set	Ground Fault Detector, all types
G	9	1	1	Car Set	High voltage fuses
G	10	1	1	Car Set	Battery box assembly, including sliding tray (if applicable)
G	11	1	1	Car Set	Battery, set complete
G	12	1	1	Each	Emergency Battery cut out switch
G	13	1	1	Each	Auxiliary inverters, complete
G	14	1	1	Car set	Aux Inverter printed circuit boards
G	15	1	1	Car set	Aux inverter power semiconductor modules
G	16	1	1	Each	LVPS, complete (if separate)
G	17	1	1	Car set	LVPS printed circuit boards (if separate unit)
G	18	1	1	Each	Knife switch assembly, complete (if DC shop power arrangement used)
G	19	1	1	Car Set	Car mounted shop power plug assembly, complete
G	20	6	6	Each	Matching shop power plug for above
G	21	1	1	Each	Line filters with charging apparatus, all types
G	22	1	1	Car Set	Ground brush assembly, complete
G	23	2	2	Car Set	Ground brushes, set per assembly
G	24	2	2	Car Set	Ground brush springs, set per assembly
G	25	2	2	Each	Collector ring, grounding interface
H - Propulsion and Vehicle Control					
H	1	1	1	Each	Propulsion / Dynamic Braking Resistors assembly, complete
H	2	2	2	Each	Propulsion AC Inverter, complete with enclosures
H	3	1	1	Car Set	Control relays and sensors all (including speed sensors)
H	4	2	2	Each	Electronic control for traction inverter, complete

SPARE PARTS					
	Item No.	**Qty**	**Qty (Recommended by CAF)**	**Unit**	**Description**
H	5	1	1	Car Set	Printed Circuit Cards for propulsion system, all
H	6	1	1	Car Set	Inverter ventilation motors (if applicable)
H	7	1	1	Car Set	Power semiconductor assemblies
H	8	10	10	Car Set	Ventilation replaceable air filters (if applicable)
H	9	1	1	Car Set	Printed Circuit Cards for vehicle control processor(s), all
H	10	1	1	Each	Vehicle Control Unit
I - Truck Assembly and Suspension					
I	1	2	2	Each	Power truck, complete (ready to install under car)
I	2			Each	Center truck (ready to install under car), as applicable
I	3	1	1	Truck	Traction Motor, complete with coupling
I	4	1	1	Truck	Gearbox, complete with coupling
I	5	1	0	Truck	Wheel/axle set, power truck
I	6	1	0	Truck set	Wheel/axle set, center truck (as applicable)
I	7	1	1	Truck set	Motor truck axle (machined axle or axle bridge with stub axles installed, as applicable)
I	8	1	0	Truck set	Center truck axle (machined axle or axle bridge with stub axles installed, as applicable)
I	9	24	8	Each	Wheel tire (power truck)
I	10	8	0	Each	Wheel tire (center truck) (as applicable, if tire is different)
I	11	32	2	Car Set	Rubber wheel blocks or rings, each type
I	12	1	1	Car Set	Primary Springs
I	13	1	1	Car Set	Secondary suspension springs
I	14	1	1	Car Set	Suspension dampers/shock absorbers
I	15	1	1	Car Set	Track brake supports
I	16	5	5	Car Set	Truck / suspension height adjustment shims
I	17	2	2	Car Set	Grounding cable
I	18	1	1	Car Set	Hydraulic leveling elements, complete w/ fittings and any hoses
I	19	1	1	Car Set	Leveling sensor, complete with linkage
I	20	2	2	Car Set	Flange lube system spares
I	21	1	1	Car Set	Truck area- underfloor external insulation
I	22	1	1	Car Set	Lateral stops

SPARE PARTS

	Item No.	Qty	Qty (Recommended by CAF)	Unit	Description
J - Friction Brake and Leveling Control					
J	1	2	1	Car Set	All friction brake equipment (except connecting hoses, fittings, inter-unit wiring, electronic control unit, and hydraulic pressure control unit)
J	2	5	5	Car Set	Brake pads with backing plates (in addition to Item 1)
J	3	1	1	Each	Hydraulic pump, complete
J	4	1	1	Each	Hydraulic Pressure Control Unit (HPCU), complete
J	5	1	1	Each	Hydraulic accumulator
J	6	1	1	Each	Sanding assembly, complete, including ejectors, nozzles sand hopper, heating elements, fill level sensor, and built-in compressor (as applicable)
J	7	1	1	Each	Sander control module
J	8	1	1	Each	Friction brake control unit, complete (as applicable)
J	9	1	1	Each	Leveling control unit, complete (as applicable)
J	10	2	2	Car Set	Printed circuit cards for friction brake and leveling control units
J	11	1	1	Car Set	All control relays and contactors for brake equipment
J	12	1	1	Car Set	All manually controlled valves and cocks for brake equipment
J	13	1	1	Car Set	Brake system magnet valves and pressure switches, all (in addition to Item 1)
J	14	2	2	Each	Track brake assembly, complete (including cables)
J	15	1	1	Car Set	Track brake suspension springs, elastomeric elements, and hardware / shims complete
J	16	1	1	Each	Air compressor assembly (as applicable), complete and ready to install with all hardware and controls including pressure switch
J	17	1	1	Car Set	Air Dryer units with controls (as applicable)
J	18	1	1	Car Set	Air reservoirs (as applicable)
J	19	1	1	Car Set	Miscellaneous air valves not listed above (as applicable)
K - Communications					
K	1	1	1	Car Set	Communications amplifiers (all)
K	2	2	2	Each	Audio system control head, complete (as applicable)
K	3	2	2	Each	Handset (in addition to Item 2)
K	4	5	3	Each	Gooseneck Microphone
K	5	2	2	Each	Covert Microphone
K	6	1	1	Car Set	Interior and exterior P.A. Speakers, complete with any transformers
K	7	1	1	Car Set	Speaker grills, interior (if not already included in interior linings)

SPARE PARTS					
	Item No.	**Qty**	**Qty (Recommended by CAF)**	**Unit**	**Description**
K	8	1	1	Car Set	Passenger emergency intercom station
K	9	2	2	Each	Passenger information system control panel, if applicable
K	10	1	1	Car Set	Passenger information system interior signs
K	11	1	1	Car Set	Passenger information system, exterior signs
K	12	1	1	Car Set	Passenger information system controllers including power supplies and Ethernet switches
K	13	1	1	Car Set	CCTV cameras / monitors, all
K	14	1	1	Car Set	CCTV recorder (if separate)
K	15	1	1	Each	Event Recorder assembly, complete
K	16	3	3	Each	Event Recorder Data Cartridge (if applicable)
K	17	5	5	Each	Event Recorder Data Cartridge Key (as applicable)
K	18	1	1	Car Set	Passenger Stop Request Button (all)
L - Interior and Exterior Appointments					
L	1	2	2	Car Set	Windshield
L	2	1	2	Each	Cab side window LH & RH
L	3	1	1	Car Set	Body side windows
L	4	1	1	Car Set	Door windows (separate from glass installed in spare doors)
L	5	4	4	Each	Glazing strip, windshield (as applicable)
L	6	4	4	Each	Glazing strip, cab window (as applicable)
L	7	2	2	Car Set	Glazing strip, side window (as applicable)
L	8	2	2	Car Set	Glazing strip, door window (as applicable)
L	9	1	1	Car Set	Doorway windscreens
L	10	1	1	Car Set	Seat bottom insert
L	11	1	1	Car Set	Seat back insert
L	12	1	4	Each	Single seat, complete
L	13	2	2	Each	Double seat, complete
L	14	1	1	Each	Flip-up seat, complete
L	15	1	1	Each	Multiple seat, complete, if applicable
L	16	1	1	Car Set	Interior ceiling panels, all
L	17	1	1	Car Set	Interior wall linings, all
L	18	1	1	Car Set	Separate interior moldings, all
L	19	1	1	Car Set	Interior and exterior air intake and exhaust grills
L	20	1	1	Car Set	Floor covering (Equivalent amount in rolls, with appropriate amount of welding rod for seams, and any cove supports)
L	21	1	1	Car Set	Any separate flooring cove moldings
L	22	1	1	Car Set	Exterior Skirts- upper (window line and above, including camera housing and roof area)

SPARE PARTS

	Item No.	Qty	Qty (Recommended by CAF)	Unit	Description
L	23	2	1	Car Set	Exterior Skirts- lower (below window line, including bogie skirts and coupler / bumper area skirt)
L	24	4	2	Each	Exterior Skirts- coupler / bumper area (extra in addition to line above)
L	25	1	1	Car Set	Covers for exterior and interior equipment enclosures (all)
L	26	1	1	Car Set	Stanchions and rails (all horizontal and vertical sections plus all fittings, including any wheelchair backrests)
L	27	1	1	Car Set	Passenger standee hand straps
L	28	2	2	Each	Cab door, complete
L	29	5	5	Car Set	Cab sunblinds
L	30	2	2	Each	Cab coat hook
L	31	1	1	Each	Cab waste receptacle
L	32	2	2	Each	Cab seat complete
L	33	25	25	Each	Master controller key
L	34	25	25	Each	Crew key
L	35	25	25	Each	Maintenance key
L	36	1	1	Car Set	Interior and exterior lock assemblies not part of spare parts
L	37	1	1	Car Set	Exterior and Interior Graphics, all
N - Miscellaneous					
N	1	1	1	Car Set	All seals and gaskets not included in specific subsystem spares
N	2	1	1	Car Set	All air, hydraulic and pneumatic filters not included within specific subsystem spares
N	3	1	1	Car Set	All fuses not included within specific subsystem spares
N	4	1	1	Car Set	All fuses holders not included within specific subsystem spares
N	5	1	1	Car Set	All pneumatic and refrigerant hoses and lines (including fittings) not included in specific subsystem spares
N	6	1	1	Car Set	Wire and cable of all types used on the car in lengths equal to total amount of car.
N	7	1	1	Car Set	All vehicle control high voltage contactors, control modules, and low voltage relays not included in specific subsystem spares
N	8	4	4	Car Set	All special fasteners not commercially available
N	9	1	1	Car Set	All special and commercially available terminals and connectors for wire and cable
N	10	1	1	Unit	All lubricants (oil and greases) necessary to maintain the vehicles per the O&M Manual (1-year supply)

SPARE PARTS

	Item No.	Qty	Qty (Recommended by CAF)	Unit	Description

SPECIAL TOOLS

	Item No.	Qty	Qty	Unit	Description	
ST	1	3	3	each	Portable Test Unit (hardened laptop) with diagnostic software for all vehicle subsystems installed, any required interface cables provided.	
ST	2	1	1	each	Portable brake test unit (for test / troubleshoot / remote operation of EHU)	
ST	3	1	1	each	Air comfort system - Refrigerant Recycling Station + special tools	
ST	4	1	1	each	Hydraulic flush / fill / contamination monitor cart, complete	
ST	5	1	1	each	Hydraulic fill cart	
ST	6	1	1		Hydraulic test adapter and hose kit, including accumulator adapters, as needed.	
ST	7	1	1	each	Battery charger	
ST	8	1	1	each	Wheel Profile Digital Measuring Tool	
ST	9	5	5	each	Wheel profile metal inspection gauges	
ST	10	2	2	each	Wheel Tire Changing tool	
ST	11	0	0	each	Ultrasonic Test Equipment	Not necessary- streetcar has no axles
ST	12	1	1	each	Damper Test Equipment	
ST	13	1	1	set	Cable connector tools for all vehicle connectors	
ST	14	1	1	set	Rerailing equipment (describe equipment to be provided)	
ST	15	2	2	set	Lifting pins (for lifting car using slings on crane) with jack socket adapters	
ST	16	1	1	each	Pantograph tension gauge	
ST	17	1	1	each	Door closing force tester	
ST	18	1	1	each	TWC test box	
ST	19	4	4	each	Brake mechanical manual release tool, if applicable	
ST	20	1	1	each	Pad force measuring tool	
ST	21	1	1	each	Any special tooling required for traction motor / gearbox removal / installation	

APPENDIX DD.4

Quality Assurance Plan

ISSUE CONTROL / DISTRIBUTION

ISSUE	REASON	DATE
-	First issue	06/MAR/2013
A	Update according to CINCAF 38 letter comments	25/JUN/2013
B	Update according to CINCAF 153 letter comments	31/JUL/2014

DISTRIBUTION

Ignacio Olivera (Project Manager)
Miguel Artigas (Technical Project Manager)
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City Of Cincinnati

Prepared by:	Revised by:	Approved by:
Name: David Paricio	**Name:** Ramón Ichaso	**Name:** Claudio Garcia
Date: 31/JUL/2014	**Date:** 31/JUL/2014	**Date:** 31/JUL/2014
Signature:	**Signature:**	**Signature:**

INDEX

1. INTRODUCTION

- **PURPOSE**

The Quality Plan describes the procedures and controls that will be applied by Construcciones y Auxiliar de Ferrocarriles, S.A. (CAF) in order to satisfy the requirements of the Agreement between CITY OF CINCINNATI and CAF to design, manufacture and delivery of five low floor streetcars for CITY OF CINCINNATI.

The present document is titled "**Quality Assurance Plan**" and it will subsequently be supported by a specific "**Test and Inspection Plan**".

- **SCOPE**

This Quality Plan is mandatory on all stages of the contract from initial review of the contract to delivery of the trains.

2. RELATED DOCUMENTS

- ISO 9001/2008 Quality Systems

- CAF Quality Assurance Manual, Vehicles Division

- CAF Procedures Manual

3. GLOSSARY

• CAF:	Construcciones y Auxiliar de Ferrocarriles, S.A.
• Purchaser:	CITY OF CINCINNATI
• Quality Manual:	A document setting out the Quality Assurance policies and management organization for the execution of the contract
• Test and Inspection Plan:	A document setting out the specific inspections and quality controls to be carried out at every stage of the project

4. QUALITY SYSTEM

The project will be undertaken within the framework of the quality assurance requirements detailed in the International Standards Organization specifications ISO 9001:2008, and FTA-IT-90-5001-02 QA/QC.Guidelines.

Lloyds Register Spain, registration number 950266, registers CAF as satisfying the requirements of UNE EN ISO 9001:2008.

The Quality System of CAF is detailed in the Quality Manual. This manual contains a Quality Policy Statement signed by the General Manager, see section 5. MANAGEMENT RESPONSABILITIES.

The Quality Manager holds copy of this manual.

- **DOCUMENT REVIEW**

  Prior to submission to the Purchaser this document has been reviewed by and approved by the Project Manager and the Quality Manager.

- **PROCEDURES**

  Documented procedures will be used according to the Quality System to control all the processes employed in every stage of the project.

  These procedures are included in the Procedures Manual. A list of these procedures is also stated in Appendix 1.

5. MANAGEMENT RESPONSABILITIES

- **QUALITY POLICY**

The Quality Policy applicable to the supply of Railway Vehicles has the objective of supplying products and services conforming to our Customer's and legislative requirements.

To achieve this objective, this Quality Management System has been implemented as a device that allows the provision of objective proof in the form of data and information on the efficiency of our organisation and quality of our products. This shall lead to:

- *Our Company attaining the desired quality at an optimum cost.*

- *Our Customers' increased satisfaction and their trust in our products.*

The maintenance of this Quality Management System will allow us to establish "solid bases" on which the required activities shall be developed to promote the continuity and progressive improvement of our Company.

I request each Division and Department involved to strictly comply with the Quality Assurance Programme described in this manual.

Signed: Andrés Arizkorreta

General Manager

CAF Procedure P-02.01-BZ “Structure and Organization” describes and establishes in detail the functions and responsibilities for each of the CAF Departments Managers.

Within the procedure P-05.05.BZ “Organization, planning and development of the project” it is established the appointment and entitlement of the CAF key staff who will constitute the Project Team, additionally to the Project Manager, Quality Project Manager and Project Lead Engineer. The Engineering department constitutes as well different working teams and managers for each sub-department in the Technological Area.

- **Responsibility, Authority**

Responsibility and Authority

The functions, responsibilities and relations of the personnel involved in all those activities related to Quality are defined in procedure **P-02.01-BZ “Structure and Organization”**.
Departamental charts are available on the computer-based network.

The activities described in the previous procedure include all stages of the project cycle, from the identification of the Customer requirements, to design, manufacture, repair/rehabilitation, delivery, and after sales service of railway vehicles.

Management Representative

CAF, S.A. Management takes on the direction, coordination, support and promotion of the activities to ensure the quality of the products and services supplied to the Customer.

The responsibility of the whole **CAF, S.A.** organization and, in particular, of its directors is to meet what is established in the Quality System.

The responsibility for monitoring of the ongoing application of the policy, procedures, standards, criteria and records included in this Manual and in the Procedures is of the Quality Director of **CAF, S.A.** by delegation of the General Management, having the necessary authority and autonomy to:

a) Ensure that all the Quality System requirements are established, implemented and maintained.

b) Inform the Management of the Quality System’s operation, for its revision and to lay the basis on which to improve the Quality System.

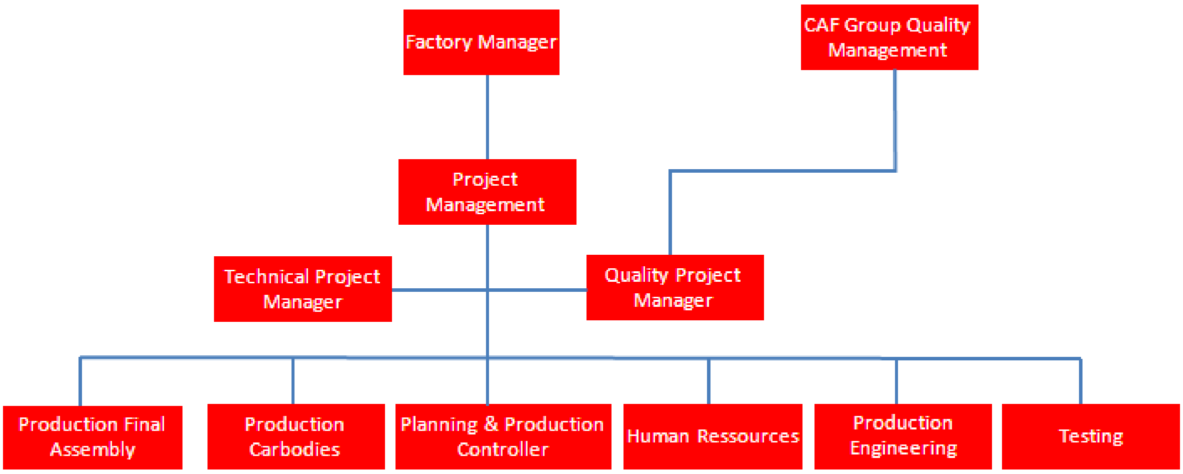
c) Solve quality related issues or stop design, manufacturing, commissioning or service operations in the case they wouldn’t meet critical requirements.

Signed: **Andrés Arizkorreta**
CEO General Manager

- **Organization Chart**

The Organization Chart of the Project it is included into CAFCIN-7 [CDRL 18-2] Management Plan Ed -, APPENDIX B. PROJECT ORGANIZATION CHART.

Find attached Organization Chart of QA level of independence/autonomy in CAF organization



CINCINNATI STREETCAR

6. TRAINING OF CAF PERSONNEL

Comprehensive training programmes are conducted to ensure that all CAF personnel are trained to a level commensurate with the tasks placed on them. The training is conducted for both technical and management skills. Training Programmes are coordinated by the Training Department.

The resumes of all the Contractor's QA personnel engaged in this Contract are going to be submitted for the City of Cincinnati approval.

7. PLANNING

- **CONTRACT REVIEW**

A contract review will be undertaken within the 3 months after the Contract signature or as described in other formal specific agreement between CAF and the Purchaser. The purpose of this review is to ensure that the requirements of the Contract are clearly understood by the project team, and can be achieved effectively and to ensure due emphasis is placed on the Quality requirements by all personnel involved in the Contract.

- **PROJECT TIME PLANS**

A Project Time Plan will be prepared for the Project and will include relevant input from major sub-contractors. The plan will show the design stages and time scales identifying key events in the program such as Design Review, Manufacturing, Factory Acceptance Testing, Transport, Delivery,

Commissioning and Acceptance testing. These processes are detailed in the related procedures

- P-05.05.BZ “Organization, planning and development of the project”

- P-05.02-BZ “Design development”

- P-05.03-BZ “Design verification and validation”

- P-05.04 BZ “Design Review”

These procedures are CAF's internal documentation, own of the system of ISO Quality 9001/2008 of CAF, not being able to be distributed. However City has access to these Procedures.

Documents to be furnished by the Contractor for approval by the City shall include, but not be limited to, those listed in TS18.6.5 in addition to those noted as CDRLs in Sections 2 through 18. The City reserves the right to request additional documents, as required, to clarify and amplify the intent of the vehicle design.

The Project Time Plan of the Project it is included into CAFCIN-7 [CDRL 18-2] Management Plan Ed -, -, APPENDIX E. PROGRESS SCHEDULE.

- **PROJECT REPORTING**

The Project Manager will report to the Purchaser about the status of the project at every project status meeting.

Senior management meetings will be scheduled on a regular basis.

CAF is responsible to prepare and provide a Monthly Progress Report and also is responsible for preparation of all Meeting Minutes during this project.

8. DESIGN & DEVELOPMENT CONTROL

- **GENERAL**

All stages of the design will be documented. The procedures to be adopted during these stages are specified in the Quality Manual and supporting documentation.

- **DESIGN AUTHORITY**

The Design Authority is responsible for ensuring that the performance of the units satisfies both the design requirements and the contract conditions.

The Design Authority for this contract is the Project Lead Engineer.

- **INTERNAL DESIGN REVIEW**

  The Design Review Process will be employed to rigorously assess the suitability of the design for its intended task. Internal Design Reviews will be held at predetermined stages in the design.

  The Design Review Process which will be employed is detailed in the procedure:

  - P-05.04-BZ “Design review”

- **EXTERNAL DESIGN REVIEW**

  External Design: Design made by CAF suppliers.

  In addition to the Internal Design Review process, External Design Reviews will also be undertaken with the Purchaser or representatives, according to the Contract as detailed in the Project Time Plan, and will be used as the control mechanism to formally approve the Design.

- **MONITORING AND ASSESSMENT**

- Performance monitoring of the rolling stock will be undertaken to record all defects, procedure is going to be follow, to solve the defects. Defects are addressed through the Nonconformance procedures P-14.01-BZ “Handling of Non-Conformities detected in production” and P-14.02-BZ “Handling of Non-Conformities detected in incoming inspection”

  This occurs, during test and inspection plan for incoming goods, during manufacturing, after manufacturing and during the warranty.

- **CONFIGURATION MANAGEMENT & CHANGE CONTROL**

  Configuration Management will be adopted to ensure control of all documentation, drawings, hardware and software.

  Configuration management process is detailed in the procedure:

  - P-05.01-BZ “Modifications”
  - N-07.03-BZ-03 “Software Quality Assurance Plan”
  - N-07.03-BZ-04 “Configuration Management of Fundamental External Stock Elements (EFAE)”

- **CONCESSIONS**

  All concessions will be dealt with according to the contract. This will cover all changes to the contract and must be agreed by both parties before carrying out the change.

  ECR form (See CDRL 18-45 ECR Form into CAFCIN 0025) is going to be used for this purpose.

9. PURCHASING

- **VENDOR CONTROL**

  The term “Vendor” includes suppliers of proprietary products and sub-contractors who supply products and services specifically tailored to the requirements of this project i.e. non-proprietary.

  According to the Quality System all vendors are approved by CAF prior to contracts being placed and a list of approved vendors will be held within the Purchasing Department.

  In the Inspection Plan For Incoming Goods (within the Test and Inspection Plan) it will be stated the controls imposed over each purchased material.

  List of vendors will be submitted to the City

- **PURCHASE ORDERS**

  Purchase orders will only be placed with approved vendors according to CAF procedures. Orders need to be approved prior to issue.

- **PURCHASER SUPPLIED MATERIAL**

  Should any material be free issued by the Purchaser for use on the units then it will be held in store under the same conditions and procedures as for all other material required for the Project, except for being labelled as a Purchaser owned property. The processes are detailed in the procedure:

  - P-08.01-BZ “Products supplied by the Purchaser”

10. MANUFACTURING CONTROL

Manufacturing will take place in accordance with the relevant documented procedures, a list of which is given in Appendix 1.
Manufacturing control procedures are mandatory on all stages of the manufacturing process and are supplemented by detailed work instructions where required.

- **SPECIAL PROCESSES**

  Within the project the below listed “Special Processes” are defined.

The “Special Processes” are those which require a particularly detailed level of work instructions or operator skills in order to ensure that quality, safety and reliability is achieved. As the design advances additional Special Processes may be identified.

- Painting Procedure: P-10.03-BZ “Checking Painting Processes”

- Welding Procedure: P-10.04-BZ “Checking Welding Processes”

- Cable Preparation Procedure: P-10.11-BZ “Checking Cable Preparation Process”

- **QUALITY RECORDS**

General Records: Records of the performance of the Quality System are held in accordance with the requirements of ISO 9001:2008.

Project Specific Records: In addition to the above recording, project specific information will also be held including:

- Contract Review

- Design Reviews

- Drawings

- Test Reports

- Spare Parts

- Manuals

QC will document in accordance with TS18.8.3, all Inspection and test activity and capture any and all discrepancies found and that his information shall be included in the Car History Book.

QA will monitor and ensure that all inspection, test and engineering documentation for each/ every car of the project, according to the Test and Inspection plan, will be included in the Car History Book.

The described Quality records and the essential ones to the effective operation of this project will be available for review by the City for a minimum of three years after the vehicle is placed in revenue service.

- **TEST AND INSPECTION PLAN**

According to the Quality System a Q.41.96.902. Test and Inspection Plan will be produced to identify the controls to be applied at all stages of the project.

This Test and Inspection Plan will be composed of:

- Receiving inspection: Inspection Plan For Incoming Goods, in following procedures it´s defined responsibility for verifying conformity of the supplied product to requirements before using it in the constructed works:

P-11.03-BZ “Reception Inspections and Testing”

VhGpGs_P311 “First Article Inspection (FAI)”

- Test and Inspection Plan For Manufacturing.

In-process inspection: At the inspection and Testing Plan it´s defined responsibility for in-process inspection. Subsequent documentation is produced:

• Control Record: Record to be signed at least by Production departments and Quality Assurance which justifies the fulfilment of the requirements defined.

• Control Sheet: Internal Control document of the different manufacturing stages.

Final Inspection: At the inspection and Testing Plan it´s defined responsibility for final inspection and subsequent record.

- Final Tests Plan (including factory and in-track testing).

Following points of inspections agreed with the Customer at the Inspections and testing Plan:

- Witness Point (W): Point in the I&T Plan agreed with the customer to be noticed. There is no need to stop the production activities independently of the customer’s assistance.

- Hold Point (H): Point in the I&T Plan agreed with the customer to stop the production activities until its customer’s witness, unless there is a documented refusal.

The Test and Inspection Plan will be submitted to the Customer for review and approval.

- **PROJECT DOCUMENTATION**

Project specific documentation will be prepared as appropriate in agreement with the Purchaser.

- **DOCUMENT CONTROL**

Document Control will be undertaken in accordance with the operating procedures of CAF Quality System, within the quality assurance requirements detailed in the ISO 9001:2008.

11. IDENTIFICATION AND TRACEABILITY

Part identification will ensure that all components and sub-assemblies are controlled and ensure that only the correct part will be fitted to a higher level assembly.
Major assemblies will be marked with a serial number to ensure traceability of all assembly, inspection and test processes.

CAF will provide a complete list of components requiring serialization that will have been agreed to at the project level.

12. INSPECTION

- **INSPECTION PLAN FOR INCOMING GOODS**

  The controls imposed to the purchased materials will be stated in the Inspection Plan For Incoming Goods (within the Test and Inspection Plan).

  Inspection of all purchased materials and products is controlled by applicable procedures which identify the inspection criteria to be applied. Where applicable the procedures may be implemented prior to the material or product leaving the vendor's premises i.e. source inspection.

  Any work found to be unacceptable would be subject to the following courses of action:

  - Repair: Product corrected to allow use, but not brought back to approved configuration. Require Customer approval

  - Rework: Product corrected and brought back to the original approved configuration.

  - Material accepted by concession = Use as is. Require Customer approval

  - Scrap

  - P-11.03-BZ "Income Inspection and Testing of Materials"

  - P-14.02-BZ "Handling of Non-Conformities detected in incoming inspection"

  - VhGpGs_P311 "First Article Inspection (FAI)"

- **TEST AND INSPECTION PLAN FOR MANUFACTURING**

  The controls imposed to the manufacturing process will be stated in the Test and Inspection Plan For Manufacturing (within the Test and Inspection Plan).

  Inspections at the appropriate stages defined in the Test and Inspection Plan will be undertaken to the appropriate standards.

  - P-11.01-BZ "Production Quality Planning"

In-process inspection: CAF quality assurance organization will maintain and direct a force of inspectors to verify that work in its shops is performed in compliance with the approved design drawings and Technical Specifications.

Final Inspection: After all work is completed, the CAF performs its own final inspection to written procedures prior to the City's inspection. Workmanship items covered by prior inspection reports are corrected before final inspection begins. Before shipment from the CAF's plant to the City's facility, final inspection is carried with the City's representative, who will be accompanied by a qualified supervisor to assure that proper corrective action are taken.

Pre-Shipping Inspection: Subsequent to final inspection by the City and resolution of any outstanding items, CAF will prepare each vehicle so as to preclude damage during shipment. Inspections will be conducted for vehicles scheduled for shipment to confirm that all shipping precautions and checks have been accomplished.

Post-Shipping Inspection: Upon arrival of each vehicle on the tracks at the City's facilities, CAF will inspect the vehicle for any damage or evidence of anomalous conditions during shipping.

- Final Tests Plan (including factory and in-track testing).

QA will:

- document in accordance with TS18.8.3 all inspection and test activity and capture any and all discrepancies found

- monitor and ensure that all of the project, inspection, test and engineering documentation for each/ every car is recorded

and this information will be included in the Car History Book, according Inspection and Testing Plan Q.41.96.902.

13. TESTING

Testing will be carried out in accordance with the Final Tests Plan included in the Test and Inspection Plan.

The Test and Inspection Plan will include factory and site tests, type and routine tests.

- P-11.02-BZ "Final Tests and Trials"

14. CONTROL OF INSPECTION, MEASURING AND TEST EQUIPMENT

Inspection, measuring and test equipment used for product verification is periodically reviewed and calibrated.

The calibration process and the calibration period are stated in the procedure:

- P-12.01-BZ "Checking inspection, measuring and testing equipment"

15. HANDLING, STORAGE, PACKING AND DISPATCH

Finished products, having been finally inspected will be stored, packed and dispatched in such a manner that no deterioration is guaranteed.

The process to manipulate, store, pack and deliver finished products will be conducted according to the procedure:

- P-16.01-BZ "Handling, storage, packaging and delivery".

16. COMMISSIONING

Any commissioning activity will be undertaken in accordance with the corresponding procedures.

- P-11.02-BZ "Final Tests and Trials"

17. ACCOMMODATION AND ASSISTANCE

The Purchaser or his representative will have access to all facilities used during all stages of the Project. It will be made available the following (the list of materials that will be provided to the City and its Representative is to be considered a minimum list that will be adjusted as needed):

- Drawings and documents required for Design Review.

- Manuals, procedures and instructions used within the Project.

- Production and delivery schedules.

- Change notices,

- Non-conformance reports,

- And any other project/QA/QC document or record required to perform the required tasks.

The City will, at its option, monitor any or all Contractor activities and inspect or test any or all equipment. The Contractor will not hinder or limit such activities. The City will have access to all designers, subcontractors, and suppliers. The City will have the right of free access to facilities of the Contractor and subcontractors.

18. MEASUREMENT, ANALISYS AND IMPROVEMENT

- **CUSTOMER SATISFACTION**

These activities will be performed in accordance with the procedure:

- P-08.02-BZ "Customer satisfaction measurement".

- **CONTROL OF NON-CONFORMING MATERIAL**

All non-conforming material will be identified and returned to its place of origin. This may be either an external supplier or an internal department.

The process to document and dispose of non-conforming materials will be conducted according to the following procedures:

- P-14.01-BZ "Treatment of unsuitable products detected during manufacture"

- P-14.02-BZ "Treatment of unsuitable products at reception"

- **QUALITY AUDITS**

Regular internal quality audits are conducted within the Quality System in accordance with the operating procedure:

- GeSgCa "Quality Management System, Internal Audits"

APPENDIX 1. CAF'S PROCEDURES

These procedures are Caf's internal documentation, own of the system of ISO Quality 9001/2008 of Caf, not being able to be distributed. However, can be analyzed maintaining a meeting.

CODE	DESCRIPTION
P-02.01-BZ	STRUCTURE AND ORGANISATION
P-03.01-BZ	QUALITY PLANNING
P-04.01-BZ	CONTRACT REVIEW
P-05.01-BZ	MODIFICATIONS
P-05.02-BZ	DESIGN DEVELOPMENT
P-05.03-BZ	DESIGN CHECKING AND VERIFICATION
P-05.04-BZ	DESIGN REVIEW
P-05.05-BZ	ORGANISATION, PLANNING AND DEVELOPMENT OF THE PROJECT
P-06.01-BZ	PROCEDURE PREPARATION AND CHECKING
P-06.02-BZ	DOCUMENT CHECKING
P-07.01-BZ	APPROVING SUPPLIERS
P-07.02-BZ	SUPPLIERS QUALITY SYSTEM AUDITS
P-07.03-BZ	PURCHASE MANAGEMENT OF MAIN EQUIPMENTS
P-07.04-BZ	PURCHASE DOCUMENTS
P-07.07-BZ	CONTINUAL DELIVERY ASSESSMENT
VHGPGS_P311	"FIRST ARTICLE INSPECTION (FAI)"
P-08.01-BZ	PRODUCTS SUPPLIED BY THE PURCHASER
P-08.02-BZ	CUSTOMER SATISFACTION MEASUREMENT
P-09.01-BZ	IDENTIFICATION AND TRACEABILITY
P-10.01-BZ	PREPARATION AND PUBLICATION OF PARTS LIST
P-10.02-BZ	CHECKING FINISHED PRE ASSEMBLY AND ASSEMBLY PROCESSES
P-10.03-BZ	CHECKING PAINTING PROCESSES
P-10.04-BZ	CHECKING WELDING PROCESSES
P-10.05-BZ	CHECKING STRUCTURE PROCESSES
P-10.07-BZ	CHECKING BOILER-SHOP PROCESSES
P-10.08-BZ	IRON/STEEL SURFACE TREATMENT
P-10.09-B	CHECKING FINISHED BOGIE ASSEMBLY PROCESS
P-10.11-BZ	CHECKING CABLE PREPARATION PROCESS
P-10.12-B	CHECKING TUBE MANUFACTURING PROCESS

CODE	DESCRIPTION
P-10.13-BZ	MAINTENANCE OF MANUFACTURE EQUIPMENTS
P-10.14-B	CHECKING OF MECHANISING PROCESS
P-10.15-B	CHECKING ASSEMBLY PROCESS
P-10.16-BZ	CHECKING ADHESIVE AND SEALING PROCESS
P-11.01-BZ	PLANNING MANUFACTURING QUALITY
P-11.02-BZ	FINAL TESTS AND TRIALS
P-11.03-BZ	INSPECTIONS AND TESTS ON RECEPTION
P-12.01-BZ	CHECKING INSPECTION, MEASURING AND TESTING EQUIPMENT
P-13.01-BZ	INSPECTION AND TEST STATUS
P-14.01-BZ	HANDLING OF NON-CONFORMITIES DETECTED IN PRODUCTION
P-14.02-BZ	HANDLING OF NON-CONFORMITIES DETECTED IN INCOMING INSPECTION
P-15.01-BZ	CORRECTIVE ACTIONS
P-16.01-BZ	HANDLING, STORAGE, PACKAGING AND DELIVERY
P-17.01-BZ	QUALITY RECORDS
GeSgCa	Quality Management System, Internal Audits
P-19.01-BZ	TRAINING
P-20.01-BZ	TREATMENT OF T.A.S. INFORMATION
P-20.02-BZ	TRAINING OF T.A.S. PERSONNEL
P-20.03-BZ	T.A.S. MATERIAL MANAGEMENT
P-20.04-BZ	POST-SALES TECHNICAL ASSISTANCE
P-20.05-BZ	ORGANISATION OF THE POST-SALES TECHNICAL ASSISTANCE
P-21.01-BZ	STATISTICAL METHODS

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Sub-Part E – QUALIFICATION, EXPERIENCE AND REFERENCES

SECTION A CAF USA'S CAPACITY TO PERFORM THE WORK

CAF USA's owns and operates a fully functional, state-of-the-art manufacturing and final assembly production facility located in Elmira, NY. This plant has a total surface of 38 acres with more than 400,000 ft^2 of covered surface. The facility houses CAF USA's Engineering, Production, Testing and, Purchasing, and Human Resources.

Drawing on its wealth of manufacturing and assembly experience, the Elmira facility has been optimized to operate in the most productive, efficient and safe manner possible.

As seen in the chart below CAF USA has ample capacity to perform the required work for the Center City Connector project in tandem with its ongoing projects.

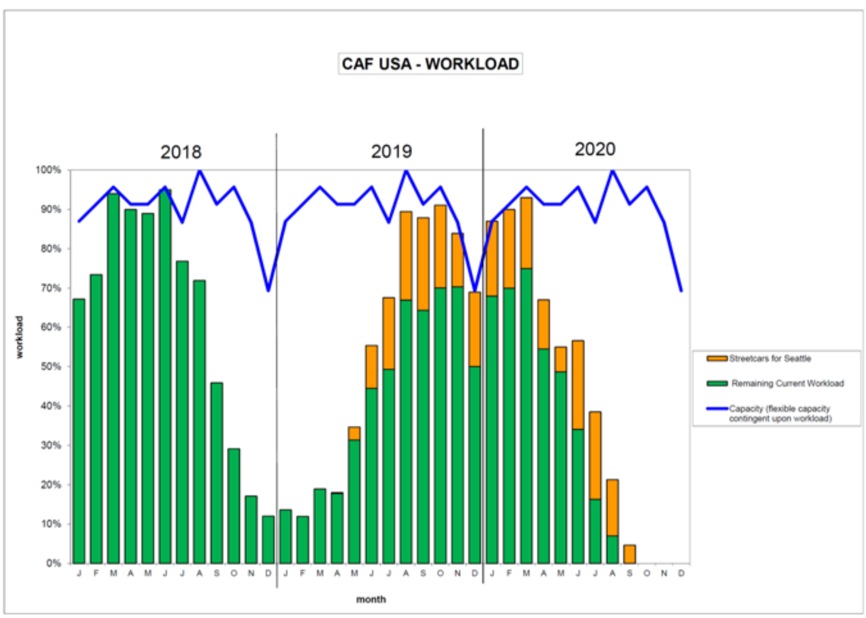

Figure 1. Elmira: Manufacturing Capacity

Additional information can be found in Sub-part C, Section D Manufacturing Plan.

A.1. ANNUAL VOLUME FIGURES (5 YEARS)

The commercial and industrial activity of the CAF Group (including CAF USA) is shown in the excerpts from the annual reports for the last five years - Appendix EA.1. Annual production volume figures for vehicles and trucks for the past 5 years for the CAF Group are also shown below.

YEAR	PRODUCTION VOLUME	
	VEHICLES	TRUCKS
2012	1088	1768
2013	697	1271
2014	874	1464
2015	852	1130
2016	560	849

Additional information is included in the annual reports for the CAF Group, which also includes the figures for CAF USA. The reports are available online at http://www.caf.net/en/accionistas-inversores/informacion-economicofinanciera/informacion-auditoria-cuentas-gestion-memoria.php

A.2. FACILITY AND RESOURCE CAPABILITIES

A.2.1 ELMIRA FACILITY - USA

The table below provides some information on the work areas in the Elmira factory. More detailed information about the capabilities of the Elmira, NY facility is included in Sub-part C, Section D - Manufacturing Plan.

WORK AREA	MACHINERY
BUILDING 4	▪ 192,000 sq. ft. ▪ (2) Two, 45 Ton Bridge Cranes ▪ 5 Ton Bridge Crane ▪ Three, 3 Ton Jib Crane
BUILDING 4	▪ 94,000 ft2. ▪ 13,700 ft2 Test area with Pits ▪ (2) Two, 40 Ton Bridge Cranes ▪ (2) Two, 25 Ton Bridge Cranes ▪ One, 10 Ton Bridge Crane ▪ Two, 5 Ton Cranes
PAINT BOOTH	▪ 2 Booths ▪ 100 ft. Long ▪ Air Filtration ▪ Pneumatic Man Lifts
WATER TEST AREA	▪ Vehicles up to 85 ft. Long, 15 ft. High & 12 ft. Wide ▪ PLC Controlled ▪ Can be easily reconfigured to accommodate Customer Requirements

WORK AREA	MACHINERY
STATIC TESTING PITS	▪ Two Pits – 4 ft. deep – 345 and 243 ft. long ▪ Power Supply: 12.500 vAC / 600 vDC / 37.5 vDC ▪ Dual Gauge Track ▪ Level Track
CLIMATE CHAMBER	▪ Temperatures from - -40° to158° F ▪ Humidity up to 100% Non-condensing ▪ 510,000BTU/per hour electric heater power- (42.5 Ton) ▪ Length: 116'2" ▪ Width: 21'
TEST TRACK	▪ 2500 ft Test Track ▪ Overhead Catenary ▪ 3rd Rail ▪ Testing at 35 mph

A.2.2 ZARAGOZA FACILITY

A listing of the capabilities of the Zaragoza factory, where the carbodies are manufactured, is shown in the table below. Additional information can be found in Sub-part D, Section D - Manufacturing Plan.

WORKSHOP	CHARACTERISTICS
CARBODIES ALUMINUM	3 BAYS / BUILDINGS Lengths:120, 165 and 190 m. Widths: 20 and 2 of 25 m. Height: 9.05 m (hook)
STEEL CARBODIES	3 bays/buildings with lengths of 160 m x 18m Hook height 7,100
STAINLESS CARBODIES	3 BAYS / BUILDINGS Lengths:200m. Widths: 1 of 23 m, 2 of 17 m. Height: 7,100 (hook)
PAINT WORKSHOP	Set of building and bays with 5.7 free height Vehicle finish and preparation area. Area for the treatment and painting of parts under carousel
PIPING WORKSHOP	Cutting and shaping rigid piping Area Pneumatic, hydraulic and flexible piping assembly Area
ELECTRIC WORKSHOP	Wiring cutting & preparation Area Electric equipment Area. Wiring Area. Material reception Area.

A.2.3 BEASAIN FACILITY

The trucks will be manufactured in the Beasain factory which has over 100 years of experience in the manufacture of rail vehicles and components. The table below provides information on the capabilities of the Beasain factory for truck manufacturing. Additional information is included in Sub-part C, Section D - Manufacturing Plan.

WORKSHOP	CHARACTERISTICS
TRUCK STRUCTURES	5 WORK BAYS
ROBOTICS WORKSHOP	1 WORK BAY
PAINT WORKSHOP	2 PAINT BAYS / 1 PAINT CABIN (33x11x5.8 m)
	AREA FOR UNDERFRAME SHOT BLASTING & PAINTING (20x50 m)
TRUCK FINISHING	3 WORK BAYS: 3 ASSY CHAINS PER BAY
TRUCK MACHINING	

A.3. CURRENT COMMITMENTS AND ONGOING PROJECTS

A.3.1 ELMIRA

Currently at CAF USA's Elmira, NY Facility, Single Level Long Distance Trains for AMTRAK, as well as 3-module LRVs for the Massachusetts Bay Transportation Authority Green Line and 5-module LRVS for the Maryland Transit Administration Purple Line project are being manufactured.

CAF USA is confident that its Elmira Facility has more than adequate resources to produce the streetcars for the City. Following is a table showing the status of CAF USA's ongoing projects.

				Cars	
Project	Country	Units	Cars	Completed	Pending
Amtrak	USA	130	130	71	59
Boston	USA	24	72	0	72
Maryland	USA	26	130	0	130

Figure 2. Elmira: Car finishing Workload and Backlog

A.3.2 ZARAGOZA

The Zaragoza facility has acquired extensive know-how and expertise in the manufacture of the URBOS vehicles; most of the carbodies for the URBOS projects are manufactured at this facility. The

table below shows the current commitments. It is a large facility with ample capacity to manufacture the vehicles for the Center City Connector project.

Project	Country	Units	Cars	Carshells Completed	Carshells Pending
EMUs Toluca	Mexico	30	150	113	**37**
Tramway Utrecht	The Netherlands	27	135	62	**73**
Metro Medellín	Colombia	22	66	64	**2**
Tramway Luxtram	Luxembourg	21	63	56	**7**
EMUs Arriva Northern	United Kingdom	43	141	2	**139**
DMUs Arriva Northern	United Kingdom	55	140	1	**139**
Tramway Canberra	Australia	14	70	15	**55**
Tramway Newcastle	Australia	6	30	0	**30**
Metro Algiers	Algeria	12	72	0	**72**
EMUs Transpennine	United Kingdom	12	60	0	**60**
Tramway Amsterdam	The Netherlands	63	315	0	**315**
Tramway Utrecht	The Netherlands	22	154	0	**154**
Tramway Schönbüchbahn	Germany	9	27	0	**27**

Figure 3. Zaragoza: Carshell Workload and Backlog

A.3.3 BEASAIN

The Beasain facility is the largest of the manufacturing facilities and the manufacture of all trucks are performed at this facility. There is more than sufficient capacity to manufacture all of the trucks required on this project.

Project	Country	Units	Trucks	Truck Frames Completed	Truck Frames Pending
EMUs CPTM	Brazil	35	576	566	**10**
Metro Chile	Chile	41	420	323	**97**
Metro Istanbul	Turkey	21	252	250	**2**
EMUs NS	The Netherlands	118	548	28	**520**
Tramway St Etienne	France	16	51	44	**7**
EMUs Toluca	Mexico	30	186	53	**133**
Tramway Utrecht	The Netherlands	27	87	32	**55**
Tramway Luxtram	Luxembourg	21	88	26	**62**
Metro Medellín	Colombia	22	132	103	**29**
HS Train - Flytoget	Norway	8	66	2	**64**
Trailer cars Caledonian	United Kingdom	75 cars	160	7	**153**
LRVs Boston	USA	24	81	0	**81**
Metro Algiers	Algeria	12	148	0	**148**
Tramway Canberra	Australia	14	45	0	**45**
EMUs Arriva Northern	United Kingdom	43	298	0	**298**
DMUs Arriva Northern	United Kingdom	55	292	0	**292**
Trailer cars Transpennine	United Kingdom	13	132	0	**132**
EMUs Transpennine	United Kingdom	12	120	0	**120**

Tramway Newcastle	Australia	6	18	0	**18**
Metro Mexico L1	Mexico	10	180	0	**180**
LRVs Maryland	USA	26	104	0	**104**
Tramway Amsterdam	The Netherlands	63	189	0	**189**
Metro Brussels	Belgium	22	134	0	**134**
Metro Quito	Ecuador	18	216	0	**216**
Tramway Schönbüchbahn	Germany	9	36	0	**36**

Figure 4. Beasain: Truck Frame Workload and Backlog

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SECTION C KEY STAFF COMMITTMENTS

The key personnel for the Center City Connector project are shown below. These individuals are selected from a pool of skilled and qualified professionals within the Management, Engineering, and Quality Assurance Departments. They all possess ample experience in the roles to be performed on this project. The résumés for the key personnel are included in Sub-part C, Section C - Résumés. The résumés provide information on the number of years of their experience within the transit industry, as well as the number of years they have been employed with the CAF. The résumés also include the percentage of time each person will dedicate to the project during the design, manufacturing and testing phases. The key personnel for this project include the following:

Program Manager – Michael Wagner: As Program Manager, Mr. Wagner will coordinate and provide leadership for the project team to ensure accomplishment of contractual requirements for lead time, cost, and scope. He will have full authority to act on behalf of the CAF and all of CAF's selected subcontractors at all tiers within the scope of the Contract. He will be on-site in Seattle during the project, and coordinate the activities of the on-site CAF USA team from the various departments.

The following key personnel, with the exception of the Contract Administrator and Project Quality Assurance Manager, all report functionally to Mr. Wagner.

Project Lead Engineer – Ramón Casalé: Coordination and leadership of the engineering work team to ensure accomplishment of contractual technical requirements are the purview of Mr. Casalé who reports functionally to the Project Manager.

System Integration Engineer: Reporting to the Project Lead Engineer, he will be responsible for the design and integration of the main electrical systems with the vehicle circuits, as well as definition of the streetcar functionality.

Testing Manager – Mr. Chris Dietterich: He is responsible for the testing and delivery procedures before the customer. Mr. Dietrich is the Manager of the Testing Department in the US.

Scheduling Engineer – Maria José Lopez: The Scheduling Engineer assists the Project Manager in the adherence to the project schedule and generation of the appropriate documentation for this purpose. Ms. Lopez is the Planning and Process Department Manager.

Production Manager – Fernando Anoro: Mr. Anoro is responsible for all of the production activities – planning and coordination and ensuring that the manufacturing of the vehicles is done on schedule.

Project Procurement Manager – Ms. Sonia Pajares: As the Project Procurement Manager, Ms. Pajares, administers and controls the supply subcontracts for the project's main outsourced systems.

Quality Assurance Director – Iker Leonet: As QA Director, he ensures that the QA staff remain independent and objective and that all quality procedures are adhered to.

Project Quality Assurance Manager – Gary Lawson: Mr. Lawson manages the application of CAF's internal procedures as well as specific quality tasks for the project.

Field Service Support / Warranty Manager – Alberto Moreno: He will ensure correct operation of trains during the warranty period, from provisional acceptance to final acceptance. Mr. Moreno is the Manager of the Technical Support Services Department in the US. He will manage the Field Service Support / Warranty Team based in Seattle.

Contract Administrator – Ignacio M. Barrenechea: Mr. Barrenechea oversees the contract negotiations and other commercial aspects of the project.

The key personnel have been preliminarily selected for the project. In the event that any of them are not available during the execution of the project, alternative candidates with similar experience and skills will be proposed by CAF and such change will be subject to the City's approval.

1.A ON-SITE STAFF

The on-site staff will be available from the beginning of the track tests until the end of warranty. They will be led by the Field Service Support / Warranty Manager. The organizational structure is shown in the chart below. Additional information can be found in Subpart D Section C, On-Site Support.

Figure 1. Warranty Team Organization Chart

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Sub-Part E – QUALIFICATION, EXPERIENCE AND REFERENCES

SECTION B DELIVERED STREETCARS OR LRVS

This section includes CAF's recent design and manufacturing experience in providing URBOS vehicles, including fleets presently under design and/or construction. Please refer to Appendix E.B.1.

1.A. URBOS & URBOS US PLATFORM

The streetcar proposed for the Center City Connector project is based on the service-proven URBOS platform with 500+ streetcars running in revenue service in 30+ cities worldwide and more specifically on the successful URBOS US platform. This platform developed specifically for the US market, apart from its technical and performance features, offers significant advantages to users, incorporating a modern design unique in the US market, a full 100% low floor streetcar that together with wide passageways and without any type of step or ramp throughout the entire vehicle makes it accessible to all types of users, and an incomparable ride comfort.

URBOS US streetcars are operating in Kansas City, MO since May 2016 with more than 1,800,000 year-to-date trips completed and an average daily ridership of 5,400 and in Cincinnati since September 2016. CAF has also URBOS LRVs orders for 50 additional LRV vehicles in Boston and Maryland.

1.B. RELIABILITY OF URBOS FLEET

Experiences gained from the +500 streetcars running in service for a number of years demonstrate that CAF is capable of meeting the RAM targets. The comparison of the reliability data between different projects is complicate as every City's transit operation is unique in terms of vehicle typology, mission profile, evaluation method, seasonal changes, and climate.

- Vehicle Typology: There are different types of vehicles designed for specific purposes (metro cars, streetcar, EMU, and others), with different features, i.e., a metro car has to travel underground and faster than a streetcar, so the equipment and architecture of these vehicles would be dissimilar. In general, metros are not exposed to the exterior conditions (sun radiation, climatic changes, debris), they have a higher mileage, and redundant systems therefore when compared to a streetcar the expected reliability values would be higher.
- Mission Profile: The mission profile of a railway project is defined among others by the following specifications: vehicle mileage per year, number of stations, time schedule, number of vehicles per fleet, number of vehicles per operation, etc. All these factors will have an impact on the reliability figures.
- Evaluation Method: There are not any standard criteria of calculating the MDBF (Mean Distance Between Failures) and the MDBSF (Mean Distance Between Service Failures) and their associated target values.

- Seasons: Seasonal changes affect failures and vehicle delays.
- Climate: The environmental conditions of the operation (moderate, cold, or hot climate) will also have a relevant impact on the reliability figures.
- Maturity of the system: At the early stages of the operational service the failure rate is higher due to the "infant mortality", as well as at the end of the useful life due to the wear of elements.

As an example, see MKBF corresponding to two URBOS projects, one of them including OESS (Project 2).

Project 1	Data year	Climate	Car per train	ACR	Fleet	Average m/year (train)
URBOS 100	2014	Continental	5	No	19	46,655 miles

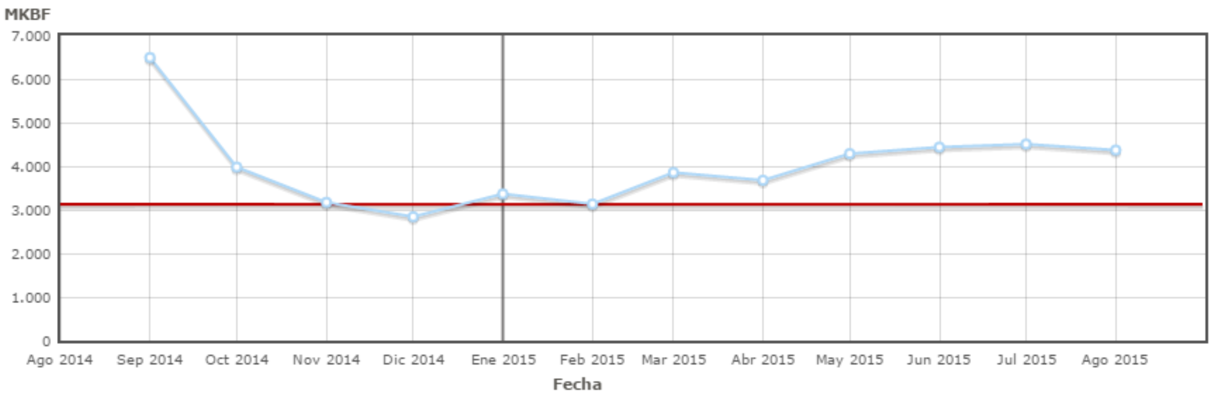

Figure 1. URBOS MKBF values achievement

Project 2	Data year	Climate	Car per train	ACR	Fleet	Average m/year (train)
URBOS 100	2016	Semi-arid	5	Yes	21	62,000 miles

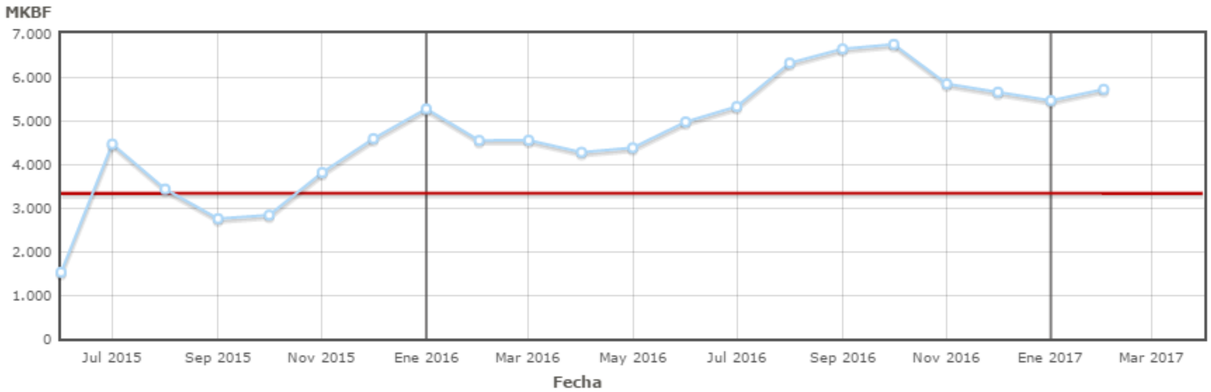

Figure 2. URBOS MKBF values achievement

The data from these two projects shows how the URBOS streetcars, after the initial period and when reaching a more mature stage (depending on the accrued miles), meets and exceeds the reliability targets defined by the customers.